BENEFICIAL REUSE OF SAN ARDO PRODUCED WATER

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SEMI-ANNUAL PROGRESS REPORT
FOR THE PERIOD APRIL 1, 2003 TO SEPTEMBER 30, 2003

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ABSTRACT

This report summarizes the work performed from 1 April 2003 to 30 September 2003 and recommends the tasks to be performed during Phase II (Pilot Evaluation). During this period discussions were held with various water agencies regarding use of the treated produced water either directly or indirectly through a water trading arrangement. In particular, several discussions were held with Monterey County Water Resources Agency, that has been charged with the long-term management and preservation of water resources in Monterey County. The Agency is very supportive of the program. However, they would like to see water quality/cost estimate data for the treated produced water from the pilot study prior to evaluating water use/water trade options. The agency sent a letter encouraging the project team to perform the pilot study to evaluate feasibility of the project. In addition, the regulations related to use of the treated water for various applications were updated during this period. Finally, the work plan, health and safety plan and sample analyses plan for performing pilot study to treat the oilfield produced water were developed during this period.

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Executive Summary

This report summarizes the work performed during the six months from 1 April 2003 to 30 September 2003. The key tasks accomplished during this period include i) Discussions with various water agencies regarding direct use of the treated produced water or indirect use of the water through a water trading arrangement, ii) Evaluation the use of the treated produced water for creating wetlands or wild life restoration, iii) Updating the regulations regarding the use, treatment and delivery of the produced water and iv) Development of plans for performing pilot study.

Discussions With Water Agencies

During this period, several discussions were held with various water agencies near the project area regarding the use of treated produced water for direct or indirect use through water trade arrangement. The agencies contacted include I) Monterey County Water Resources Agency (MCWRA), Santa Cruz Water Department (SCWD), San Ardo Water District, California American Water Company, California Water Services Company at Salinas and King City, and Pajaro Valley Water District. MCWRA is a public agency that has been charged with the long-term management and preservation of water resources in Monterey County. The Agency is very supportive of the program. However, they would like to see water quality/cost estimate data for the treated produced water from the pilot study prior to evaluating water use/water trade options. The agency sent a letter encouraging the project team to perform the pilot study to evaluate feasibility of the project. Santa Cruz Water District, located in the lower Salinas Basin, is currently planning to install desalination plants to augment their water supply. The agency expressed significant interest in the project, provided a viable water trade arrangement can be achieved, sent a letter of support to continue the pilot study to evaluate the feasibility. The other agencies preferred to reevaluate these options after the pilot study is completed.

Use of Treated Water For Creation of Wetland and Wildlife Restoration

During this period discussions were held with US Department of Fish and Wildlife Services, California Department of Fish and Games, Bureau of Reclamation, Nature Conservancy, Ducks Unlimited and Upper Salinas Watershed Coalition for the use of treated water for creation of wetland or wildlife restoration. The Bureau of Reclamation, Nature Conservancy and Ducks Unlimited do not currently have programs for these uses in the project area. The other agencies are generally interested in this project. They recommended that a survey by a biologist be performed to identify endangered species in the watershed in the project area prior to considering the possibility of creating wetlands.

Identification of Regulations for Treated Water Use

The regulations related to use of the treated water for creation of wetlands and wildlife restoration were evaluated during this period. In general, the use of treated water for all these applications involve direct or indirect discharge of the treated produced water into the Salinas River. Hence, the treated water must meet the water quality criteria defined by the Central Coast Regional Water Quality Control Board Basin Plans and the California Toxics Rule (CTR).

Development of Plans

During this period, the work plan, health and safety plan, and the sample analyses plan for performing the pilot study were developed. The work plan described the pilot equipments and components, installation and demobilization issues, and test schedule and system operational issues. The processes selected for this pilot study include warm softening to remove hardness and silica, cooling to reduce the temperature of the produced water and reverse osmosis to remove total dissolved salts (TDS) and boron. The health and safety plan identified the key plant health and safety personnel, planned site activities during the study, potential physical and hazardous material health and safety hazards, protective actions and emergency response plans. The sample analyses plan identified the sample locations, frequency, and analytes for field and laboratory analyses. It also included Quality Assurance/Quality Control (QA/QC) requirements for sample analyses.

Section 1: Introduction

This report covers the six-month period from April to September 2003. This is the second semi-annual topical report for this project. This report is designed to satisfy the topical report deliverables described in the signed Department of Energy (DOE) Notice of Financial Assistance Award for cooperative agreement No.DE-FC26-02NT15463.

1.1 Background

The overall project was divided into two phases (Phase I & Phase II). The project structure required that all the funding parties (DOE, Aera Energy LLC, or Kennedy/Jenks Consultants) approve moving forward to Phase II.

The Phase I activities started in October 2002 and is now considered by the project team (Aera Energy LLC and Kennedy/Jenks Consultants) to be completed. The project team has completed the major elements for the Phase I tasks. The Phase I activities have resulted in sufficient project progress and Aera Energy LLC and Kennedy/Jenks Consultants have made their decisions to support moving on to Phase II of the project. Therefore, the project team has three recommendations:

- DOE should approve Phase II activities.
- Move activities from Phase I to Phase II to make the project consistent and reflect two phases.
- DOE should make the project schedule consistent with the initial submitted project schedule that indicated the project would be completed in October 2004 instead of the *Notice of Financial Assistance Award* that indicates a project completion date of July 2004.

1.2 Organization of the report

This report presents the progress of Phase I activities during the last six months (April 2003 to September 2003), recommends modifications to the tasks in Phase I and II, and describes the upcoming work based on DOE approval of Phase II.

Section 1 serves as an introduction to the report. Section 2 describes in more detail the above recommendations and a potential administrative and budgetary organization for the project. Section 3 summaries the work completed during this six-month period. Section 4 summarizes the activities proposed for the next quarter of this project assuming DOE approves moving forward for Phase II.

Section 2: Phase II Recommendation and Project Restructuring

This section addresses the two project recommendations mentioned in Section 1. It also presents a project structure for Phase II and describes the source of funds for the various tasks for an approved Phase II.

2.1 Phase II Recommendation

Both Aera Energy LLC and Kennedy/Jenks recommend proceeding to Phase II of the project. Section 3 documents the project activities concerning the interest of end users for the treated water. Obtaining this interest of the potential end users was a major milestone for the project to proceed to Phase II from the perspective of Aera Energy LLC and allowed Aera Energy LLC to recommend proceeding to Phase II.

2.2 Project Restructuring

The project restructuring involves two elements. The first element is the restructuring of the project tasks by phases. The second element addresses project funding. These two elements are described below.

2.2.1 Project Task Restructuring

The Aera Energy LLC-Kennedy/Jenks Consultants team has completed Phase I of the study assuming that the recommended project restructuring of tasks is adopted. The proposed restructuring of the project is described below.

1. Due to the initial uncertainty of finding potential end users of the water, the team is proposing to move the detailed design of the pilot treatment study (Phase I, Task 4) to Phase II and link it closer to the construction activity of the pilot treatment system. The project team did not want to develop engineering drawing for the pilot plant if there was no Phase II.

2. Since the Aera Energy LLC and Kennedy/Jenks Consultant team is recommending that we proceed to Phase II, it is recommended that the technology transfer requirement (Phase I, Task 5) be moved to Phase II, Task 4, as per email from Keith Miles.

3. Applying the same project philosophy, it is also recommended that the appropriate project closure and reporting requirements described in Phase I, Task 6 be move to its parallel sister Phase II activities (Phase II, Task 5).

Tables 2-1 and 2-2 summarize the task description, the status and the recommended project restructuring action.

2.2.2 Project Funding

The Phase II portion of the study was divided into two operational periods of 4 months each (Phase IIA and Phase IIB). A preliminary analysis indicates that the project team could accomplish all the design, construction and three months of the Phase IIA field work with the initial $770,000 that has already been obligated by the DOE. This would also cover all the necessary project closure and reporting requirements. This may allow DOE some additional time to commit, authorize, etc. the additional funding of $317,369 that has been approved for this project. These funds would have to become available some time in late in the first quarter or early second quarter of 2004. These funds

would cover about 1 month of operations (Phase IIA) and all of the operations for Phase IIB of the pilot study. Table 2-3 described the tasks for the revised Phase II and the source of funds.

2.2.3 Extended Project Schedule

The original Gantt chart (See Figure 2-1) that was submitted in the kick off phase of this project indicated a project completion date of October 2004. If the full Phase II is approved, this completion date would be a more realistic project completion data rather than the July 2004 completion date indicated in the *Notice of Financial Assistance Award*.

The total project would remain the same with this extended project schedule. All the tasks identified in the revised Phase II tasks (See Table 2-3) would be performed within the existing approved project budget, assuming that all the funds are provided by DOE (the additional $317,369).

Table 2-1 Summary of Original Phase I Task Description, Current Status, and Recommended Action

Phase I Task Description	Status/Recommended Action
Task 1: Project Administration.	Done for Phase I, continued effort for Phase II
Task 2: Develop End-Use Water Options and Requirements.	Done, See below for details
Subtask 2.1: Finalize Potential End-Users and Water Quality and Quantity Constraints.	Done, summarized in this semi-annual topical report
Subtask 2.2: Establish and Resolve Regulatory Requirements for Potential End-Uses.	Done, summarized in 1st semi-annual topical report
Subtask 2.3: Establish and Resolve Regulatory Requirements for Treatment Options	Done, summarized in first semi-annual topical report
Subtask 2.3.1: Waste Stream Management.	Done, summarized in 1st semi-annual topical report
Subtask 2.3.2: Use of Recycled Caustic.	Done, summarized in 1st semi-annual topical report
Task 3: Develop Project Plans.	Done, but Hazardous Substance Plan to be done in Phase II
Subtask 3.1: Development of a Demonstration Project Work Plan.	Done, See this semi-annual topical report
Subtask 3.2: Sampling and Analysis Plan.	Done, See this semi-annual topical report
Subtask 3.3: Other Plans.	Done, but Hazardous Substance Plan to be done in Phase II
. Hazardous Substance Plan	Not needed for Phase I, but is required for Phase II
. Health and Safety Plan	Done, See this semi-annual topical report
Task 4: Design of Demonstration Plant.	One activity done, recommend moving others to Phase II
Subtask 4.1: Modify process flow diagram.	Done, summarized in 1st semi-annual topical report
Subtask 4.2: Prepare engineering drawings from process flow diagram.	Recommend move to Phase II
Subtask 4.3: Review and revise engineering drawings.	Recommend move to Phase II
Task 5: Technology Transfer Activities.	Recommend move to Phase II
Subtask 5.1: Prepare Papers for Proceedings and Slides For Preview.	Recommend move to Phase II
Subtask 5.2: Prepare Web-Based Project Descriptions.	Recommend move to Phase II
Subtask 5.3: COR Briefing Presentation.	Recommend move to Phase II
Task 6: Prepare Project Deliverables.	Done for Phase I, continued effort for Phase II
Subtask 6.1: Financial Status Reports.	Done for Phase I, continued effort for Phase II
Subtask 6.2: Topical Reports.	Done for Phase I, continued effort for Phase II
Subtask 6.3: Final Report.	Recommend move to Phase II
Subtask 6.4: Environmental Reports.	Recommend move to Phase II
Subtask 6.4.1: Hazardous Substance Plan.	Recommend move to Phase II
Subtask 6.4.2: Hazardous Waste Report. .	Recommend move to Phase II
Subtask 6.5: Property Report.	Recommend move to Phase II
Subtask 6.6: Exception Reports.	Recommend move to Phase II
Hotline Reports	Recommend move to Phase II
Technology transfer articles/conference papers and proceedings	Recommend move to Phase II
Task 7: Project Management.	Done for Phase I, continued effort for Phase II

Table 2-2 Summary of Original Phase II Task Description, Current Status, and Recommended Action

Task Description	Status/Recommended Action
Task 1: Construct Demonstration Pilot Plant.	To be performed during Phase IIA
Subtask 1.1: Construct Demonstration Pilot Plant.	To be performed during Phase IIA
Subtask 1.2: Startup/shakedown.	To be performed during Phase IIA
Task 2: Operate demonstration plant.	To be performed during Phase IIA
Subtask 2.1: Execute Phase A.	75 % with Phase IIA , 25 %t with Phase IIB
Subtask 2.2: Develop modifications as needed for Phase B.	To be performed during Phase II B
Subtask 2.3: Execute Phase B.	To be performed during Phase II B
Subtask 2.4: Demobilization of Demonstration Plant Equipment.	To be performed during Phase IIA
Task 3: Develop Conceptual Project With Planning Level Cost Estimate.	To be performed during Phase IIA
Subtask 3.1: Resolve Technical Operational Issues.	To be performed during Phase IIA
Subtask 3.2: Develop Preliminary Design.	To be performed during Phase IIA
Subtask 3.2: Develop Capital and O & M Costs.	To be performed during Phase IIA
Task 4: Technology Transfer Activities.	To be performed during Phase IIA
Subtask 4.1: Prepare Papers for Proceedings and Slides For Preview.	To be performed during Phase IIA
Subtask 4.2: Prepare National Project Award Material with Press Release Information.	To be performed during Phase IIA
Subtask 4.3: Prepare Web-Based Project Descriptions.	To be performed during Phase IIA
Subtask 4.4: COR Briefing Presentation.	To be performed during Phase IIA
Task 5: Prepare Project Deliverables.	Continued and additional effort for Phase IIA & B s
Subtask 5.1: Financial Status Reports.	To be performed during Phase IIA
Subtask 5.2: Topical Reports.	To be performed during Phase IIA
Subtask 5.3: Final Report.	To be performed during Phase IIA
Subtask 5.4: Environmental Reports.	To be performed during Phase IIA
Subtask 5.4.1: Hazardous Substance Plan.	To be performed during Phase IIA
Subtask 5.4.2: Health and Safety Plan.	Done, See this semi-annual topical report
Subtask 5.4.3: Hazardous Waste Report.	To be performed during Phase IIA
Subtask 5.5: Property Report.	To be performed during Phase IIA
Subtask 5.6: Exception Reports.	To be performed during Phase IIA
Hotline Reports	To be performed during Phase IIA
Technology transfer articles/conference papers and proceedings	To be performed during Phase IIA

Table 2-3 Summary of Revised Phase II Task Description and Source of Funds

Task Description	Source of Funds	
	Budget IIA	**Budget IIB**
Task 1: Construct Demonstration Pilot Plant.	X	
Subtask 1.1: (Original Phase I Task 4) Design of Demonstration Plant	X	
Subtask 1.2: (Original Phase I, Subtask 4.2) Prepare engineering drawings from process flow diagram.	X	
Subtask 1.3: (Original Phase I Subtask 4.3) Review and revise engineering drawings.	X	
Subtask 1.4: (Original Phase II, Subtask 1.1) Construct Demonstration Pilot Plant.	X	
Subtask 1.5: (Original Phase II, Subtask 1.2) Startup/shakedown.	X	
Task 2: Operate demonstration plant.	X	
Subtask 2.1: Execute Phase A.	75 %	25 %
Subtask 2.2: Develop modifications as needed for Phase B.		X
Subtask 2.3: Execute Phase B.		X
Subtask 2.4: Demobilization of Demonstration Plant Equipment.	X	
Task 3: Develop Conceptual Project With Planning Level Cost Estimate.	X	
Subtask 3.1: Resolve Technical Operational Issues.	X	
Subtask 3.2: Develop Preliminary Design.	X	
Subtask 3.2: Develop Capital and O & M Costs.	X	
Task 4: Technology Transfer Activities.	X	
Subtask 4.1: Prepare Papers for Proceedings and Slides For Preview.	X	
Subtask 4.2: Prepare National Project Award Material with Press Release Information.	X	
Subtask 4.3: Prepare Web-Based Project Descriptions.	X	
Subtask 4.4: COR Briefing Presentation.	X	
Task 5: Prepare Project Deliverables.	X	X
Subtask 5.1: Financial Status Reports.	X	
Subtask 5.2: Topical Reports.	X	
Subtask 5.3: Final Report.	X	
Subtask 5.4: Environmental Reports.	X	
Subtask 5.4.1: Hazardous Substance Plan.	X	
Subtask 5.4.2: Health and Safety Plan.	Not applicable, Done	
Subtask 5.4.3: Hazardous Waste Report.	X	
Subtask 5.5: Property Report.	X	
Subtask 5.6: Exception Reports.	X	
Hotline Reports	X	
Technology transfer articles/conference papers and proceedings	X	

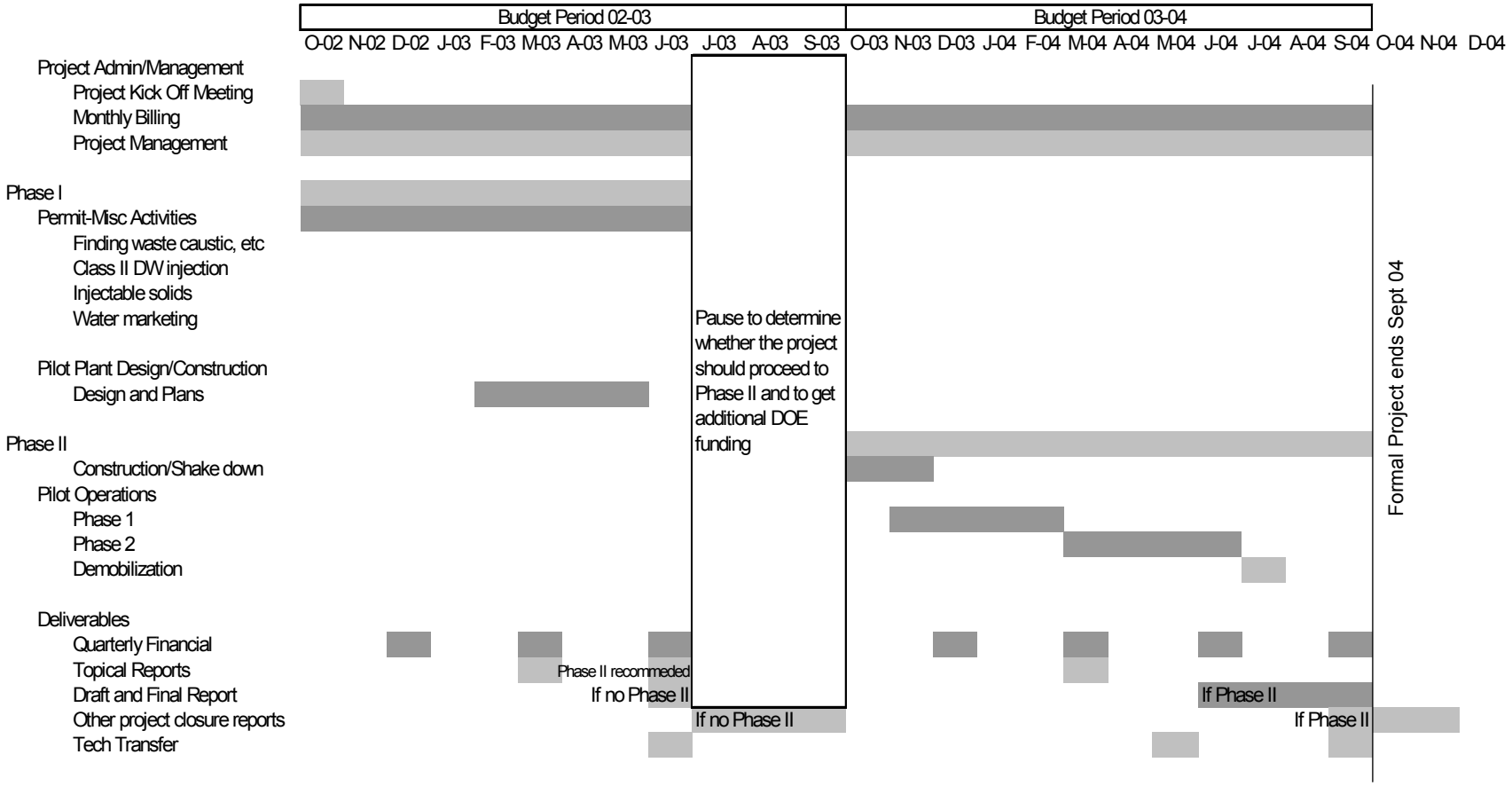

Figure 2-1. Original Submitted Gantt Chart for Phase I and II Tasks

Section 3: Task Performed During This Reporting Period

3.1 Task 2A - Identification of End Uses For the Treated Produced Water

The following activities related to identification of end use for the treated produced water were performed during the reporting period:

- Discussions were held with water agencies pertaining to direct/indirect use (via water trade) of the treated produced water. Obtained letter of support on the premise of the project and recommendations for continuing the Phase II study by key water agencies in Salinas Basin.
- Discussions were held with various agencies for use of the treated produced water for creation of wetland and wild life restoration.
- Discussions were held with local farmers regarding potential use of the treated produced water for agriculture

The agencies contacted and details of the discussions are summarized in Tables 3-1 & 3-2. Correspondence with the agencies are provided in Appendix A.

Table 3-1 Agencies contacted regarding direct/indirect use of treated produced water from San Ardo Oilfield during this reporting period

Agency	Comments
Monterey County Water Resources Agency (MCWRA)	The Monterey County Water Resources Agency is a public agency that has been charged with the long-term management and preservation of water resources in Monterey County. During this reporting period several discussions were held with the agency regarding anticipated water quality and quantity, and potential for use of the treated produced water. The Agency is very supportive of the program. However, they would like to see water quality/cost estimate data for the treated produced water from the pilot study prior to evaluating water use/water trade options. The agency sent a letter encouraging the project team to perform the pilot study to evaluate feasibility of the project. Letter of support from the agency is included in Appendix A.
Santa Cruz Water Department (SCWD)	This is a key water agency in the lower Salinas Basin. SCWD is currently planning to install desalination plants to augment their water supply. The agency expressed significant interest in the project, provided a viable water trade arrangement can be achieved, sent a letter of support to continue the pilot study to evaluate the feasibility (Appendix A).

San Ardo Water District	This is the closest water agency to the Aera Energy, LLC. It is, however, a small agency with 550 customers and 160 connections. A meeting was held with Board Members to discuss the possibility of a water trade scenario involving the agency. The agency is generally in support of the project. However, they suggested that a larger water utility that needs additional water take the initiative for a water trade arrangement that may involve San Ardo Water District.
California American Water Company	This is one of the Salinas Basin water companies that are considering installation of desalination plant to augment their water resources. Preliminary discussions were held to discuss the possibility of using treated produced water from San Ardo oilfield.
California Water Services Company – King City/Salinas	This company provides services to King City and the City of Salinas in the Salinas Basin. The company is generally in support of the project provided a viable water trade arrangement can be made.
Pajaro Valley Water Department	This is a State Chartered Agency to identify and provide supplemental water supply to Pajaro valley, which is adjacent to Salinas Basin. Contact has been initiated with the agency to discuss potential use of treated produced water from the oilfield.
Office of the County Supervisor, District 3, Monterey County	This agency is responsible for various projects including water resources and agriculture in Monterey County. Preliminary discussions were held with the agency regarding the potential benefits of the treatment and use of oilfield produced water.

Table 3-2 Summary of activities performed for the potential use of treated produced water for creation of wetland and wild life restoration

Agency	End Use Option	Comments
US Fish & Wildlife Service (USFWS)	Restoration of Riparian Oak Habitat.	The agency is generally supportive of using treated San Ardo oilfield water for riparian oak habitat provided some criteria are met. However, the water demand for this option may be lower than that generated by the project. In addition, a survey by a biologist must be done to identify endangered species.
	Seasonal (Vernal) Ponds for breeding native amphibians	May be considered under the Fish and Wildlife Partners program of the agency. Survey by biologist may be required. For both programs, USFWS would perform a Section 7 consultation under the Endangered Species Act.
Ca Dept. of Fish & Games	Restoration of Riparian Oak Habitat.	Generally interested in the project. Suggested coordination through the Upper Salinas River Watershed Resource Conservation District (non-profit, special district). Needs survey by biologist.
Bureau of Reclamation	Wetland creation.	Does not have any project in the San Ardo area. Will likely not participate.
The Nature Conservancy	Habitat Restoration	Restoration of habitat in Salinas River Basin is not a high priority. This may change if external funding is available.
Ducks Unlimited	Habitat Restoration	Ducks Unlimited does not have interest in a project in the San Ardo area at this time
Upper Salinas Watershed Coalition	Habitat Restoration	Non-profit group affiliated with Resource Conservation District focusing on stream habitat and wetlands restoration. Would be interested in participating in selected habitat restoration/ enhancement locations.

Task 2B - Regulatory Requirements

The regulations related to discharge of treated produced water were updated during this period. The following sections summarize the regulations related to delivery, use and storage of treated produced water: Table 3-3 lists the agencies responsible for various regulatory activities.

3.1.1 Regulations for delivery, use and storage of treated produced water

Water quality requirements vary with end use and mode of delivery. In addition, delivery of treated water through the Salinas River must address water rights issues for downstream users. Finally, permits related to the structural integrity of the containment basin and water quality must be obtained if the water is stored during a non-peak demand period. This section describes the agencies and regulations related to the above activities.

Table 3-3 Activities regulated and responsible agencies for delivery, use and storage of treated produced water

Agency	Activities Regulated
Central Coast Regional Water Quality Control Board (CCRWQCB)	Water/waste quality issues related to treatment, delivery, storage and end use
California Water Resources Control Board – Water Rights Division	Water rights/water allocation issues if treated water is discharged into the Salinas River
California Department of Water Resources –Division of Safety of Dams	Storage of treated water near navigable waters
US Army Corps of Engineers	Storage facilities near navigable waters for federal funded projects
Monterey County Environmental Health Department	Grading permits for decentralized storage of treated produced water
California Department of Fish and Game	Activities which alter stream flows

3.1.2 Regulations Related to Water Quality

3.1.2.1 Central Coast Regional Water Quality Control Board

The Central Coast Regional Water Quality Control Board (CCRWQCB) is the major regulatory agency responsible for overseeing the discharge of any water that could impact California water resources in this region. This authority comes from the Porter-Cologne Water Quality Control Act (Porter-Cologne) that established the California system of a State Water Resources Control Board and nine Regional Water Quality Control Boards. The CCRWQCB is one of these nine regional boards.

The CCRWQCB, in its role of implementing the State Policy for Water Quality Control, has adopted a Basin Plan that identifies the beneficial uses of the various existing water resources in the region, including surface and ground water. Any discharge from this project will most likely occur within the Salinas Hydrologic Unit. This hydrologic unit is subdivided into various sub-units and each sub-unit has its own unique set of beneficial uses.

All beneficial uses are protected by the development of water quality objectives that, in turn, are used to establish local waste discharge requirements (WDRs). The WDRs must also comply with

the existing State Implementation Policy related to the National Toxics Rule (NTR) and the specific California Toxics Rule (CTR).

Authorization from the CCRWQCB is required for any discharge that may have an impact on the region's water resources. Two types of authorizations are issued. The first is the National Pollutant Discharge Elimination System (NPDES) permit, a national program delegated to the State and Regional Boards for implementation. This permit affects any discharge to a water of the U.S. (primarily surface waters). The second is a set of waste discharge requirements (WDRs). WDRs are a California authorization intended to protect state waters not covered by the NPDES permit program. In practice, it is common for the CCRWQCB to issue one permit that covers both program requirements.

The permit requirements under various water discharge (delivery) and water use scenarios are described below:

3.1.2.2 Regulations Related to Delivery of Treated Produced Water Through the Salinas River

In this alternative, produced water for irrigation would be treated and then discharged directly to the Salinas River. The treated water would need to meet the requirements found in the following regulations and/or policy documents:

- 40 CFR 435.30 *et seq*,
- 40 CFR 435.50 *et seq,*
- National Toxics Rule (NTR), the California Toxics Rule (CTR), the State Water Resources Control Board Policy for Implementation of Toxics (Resolution 2000-015 as amended by Resolution 2000-30),
- The Anti-degradation Policy (Resolution 68-16), and
- The narrative and specific numeric water quality objectives contained in the Central Coast Basin Plan for the Salinas River and any groundwater that might be impacted by the discharge.

3.1.2.2.1. 40 CFR 435.30 et seq.

This is federal regulation promulgated by the Environmental Protection Agency (EPA) in which effluent guidelines for the oil and gas extraction industry were developed. Specifically, 435.30 *et seq.* addresses discharges from the "onshore" subcategory of the oil and gas extraction industry that are located landward of the inner boundary of the territorial seas. In paragraph 435.32, the effluent guideline states, "there shall be no discharge of waste water pollutants into navigable waters from any source associated with production, field exploration, drilling, well completion, or well treatment" to the west of the 98th meridian. Unless waste water discharge to the Salinas River is subject to other provisions contained in 40 CFR 435, the Water Board will not allow any discharge of waste water to the Salinas River.

3.1.2.2.2. 40 CFR 435.50 et seq.

This section of the federal regulations addresses onshore facilities "located in the continental United States and west of the 98th meridian for which the produced water has a use in agriculture or wildlife propagation when discharged into navigable waters". Onshore facilities in the San Ardo Field are located in the continental United States and they are located west of the 98th meridian. The wastewater will be treated before discharge to meet quality standards for use in agricultural

applications. In 435.51, the term “use in agricultural or wildlife propagation” is defined to include produced water of good enough quality to be used for agricultural uses. Discharge will be subject to certain limitations specified in 40 CFR 435.52, namely, that the produced water (after treatment) will not exceed a daily maximum limitation for oil and grease of 35 mg/l and other limitations as discussed below.

3.1.2.2.3. NTR and CTR, Water Board Implementation Policy

These two regulations and the State Board policy are intended to limit the discharge of “toxics” into navigable waters. The limits for discharge under the CTR rules are presented in EPA Federal Register (Cal. EPA, 2000). The RWQCB will require that any discharge of treated water into the Salinas River meet the requirements contained in each of these documents. Furthermore, if there is any conflict between the documents, the most restrictive requirement will be imposed on the discharge.

3.1.2.2.4. Anti-degradation Policy

The California State Water Resources Control Board adopted this policy in the late 1960s to maintain the quality of existing water resources. Under this policy, the discharge must not cause a degradation of the existing quality of the receiving water unless it has been demonstrated that the change will be consistent with maximum benefit to the people of California, that it will not unreasonably affect the present and anticipated beneficial use of such water, and that it will not result in water quality less than that prescribed in the policies.

3.1.2.2.5. Central Coast Basin Plan

Prior to discharge, the produced water will be treated to meet agricultural water quality parameters. However, the Central Coast Basin Plan contains beneficial use designations for the Salinas River that include Municipal and Domestic Water Supply (MUN) as well as Agricultural Water Supply (AG) and Industrial Water Supply (IND) uses among other uses. Therefore, the Water Board will require that the treated water meet the most stringent criteria of the narrative and specific numerical water quality objectives as identified in the Basin plan.

3.1.2.3 Delivery of Treated Water for Agricultural Irrigation by Hard Piping

In this scenario, the end user would get deliveries of the treated water for agricultural irrigation by a hard pipe. The CCRWQCB would require a WDR for this use. The treated water must meet the following water quality criteria:

- Crop water quality requirements
- Water quality requirements of the Central Coast Basin Plan

Compared with delivery through the Salinas River, there would be fewer monitoring requirements.

3.1.2.4 Discharge of groundwater into the Salinas River through water trade agreement with farm owners

Under this scenario, treated water delivered for agricultural use would be traded for groundwater. The “freed–up” groundwater would then be pumped into the Salinas River for conveyance to downstream users. The groundwater pumped into the river must meet all the requirements specified in an earlier section for the discharge of treated produced water into the Salinas River.

3.1.3 Regulations Related to Water Rights

3.1.3.1 California Water Resources Control Board – Division of Water Rights

The California Water Resources Board Division of Water Rights is responsible for ensuring that water is shared equitably with all downstream users based on historical or legally determined water rights. As such, the Division of Water Rights establishes removal quotas or pumping limits based on the adjudicated volume of water provided by the various sources. The addition of new sources of water, such as treated produced water, would likely be seen as additional water that would need to be allocated to downstream users. The process requires identification of the volume of water and the potential downstream user. The permit to appropriate the released water by the identified user will be based on the amount of water delivered and potential losses during conveyance. The proposed use of the appropriated water must also be specified. The permit application must indicate the details of the diversion works (direct diversion by pump, storage dam, etc.). The permit application should be filed once a definite plan has been formulated for construction of the project but well in advance of the construction of diversion work.

The proposed project may be subject to the California Environmental Quality Act (CEQA) which requires agencies to consider environmental effects. This process may involve obtaining a certification of exemption, a negative declaration or a preparation of a full Environmental Impact Report (EIR). The Division of Water Rights has prepared three pamphlets to provide water appropriation guidance. (State Water Resources Control Board 2000, 2000a, 2001)

3.1.4 Regulations Related to Storage

3.1.4.1 California Department of Water Resources – Division of Safety of Dams

The Division of Safety of Dams would be involved with any project that impacts “navigable” water. A “navigable” water is broadly interpreted to include any stream or ephemeral channel that is drawn on a USGS topographic map. In this role, they would be responsible to ensure that the structural integrity of any jurisdictional dam (storage structure) is adequate for its intended purpose. Furthermore, the Division of Safety of Dams would usually be the State representative of the US Army Corps of Engineers.

Water storage structures which are built solely for agricultural use and not located within a defined “navigable” water are normally not under the jurisdiction of the Division of Safety of Dams. However, the CCRWQCB would be involved because any water discharge into the storage area could have a potential impact to waters of the state, i.e. groundwater.

3.1.4.2. US Army Corps of Engineers

The Army Corps of Engineers is not normally involved in such projects unless there is direct U.S. Government funding for the construction of a dam. As such, the Army Corps of Engineers will rely upon the Department of Water Resources – Division of Safety of Dams to oversee any construction that does not involve federal dollars.

3.1.4.3 Monterey County Environmental Health Department

The feasibility of local water storage in surface impoundments (ponds) on individual farmlands was explored. In order to install a pond, a farmer would be required to obtain grading permits from the Monterey County Planning and Development Department. As part of the permit process, the farmer must submit five sets of plans for each area where ponds are planned.

3.1.4.4 Central Coast Regional Water Quality Control Board

Demand for the treated water may be seasonal, whereas the treatment process will be a year-round operation. Therefore, some type of seasonal storage alternative may be needed. Chapter 3 of California Code of Regulations (Title 27, Division 2, Subdivision 1) deals with classifications for wastes to determine where the wastes can be discharged (stored). In particular this chapter presents geologic and siting criteria for waste management units to store various waste streams. The CCRWQCB is responsible for defining the storage siting criteria if seasonal storage is required for treated produced water. However, an exemption from this requirement may be obtained if the waste (treated produced water) meets the criteria for inert waste as defined by section Ch15:§2524. An inert waste is that subset of waste that does not contain hazardous substances or soluble pollutants at concentrations in excess of applicable water quality objectives, and does not contain significant quantities of decomposable waste.

3.1.5 Regulations Related to Wildlife Protection

3.1.5.1 California Department of Fish and Game

The California Department of Fish and Game is responsible for ensuring sufficient water flow downstream of the water diversion point at all times in order to protect fish and wildlife resources. (Section 5937, Article 2, Chapter 3, Part 1, Division 6 of the California Fish and Game Code). Approval from the department may be required to obtain water appropriation by the end user.

3.1.6 Summary of Regulatory Activities

In summary, an evaluation of regulations indicated that, for delivery of treated water to the agricultural land by hard pipe, the treated water quality must meet crop water quality and basin plan water quality requirements. A WDR must be obtained from the CCRWQCB. For delivering water via the river the following are required:

- The released water must facilitate agricultural or wildlife restoration requirements.
- The water quality must be in compliance with NPDES, NTR, CTR and anti-degradation requirements.
- A permit from the State Water Resources Control Board must be obtained for water appropriation
- Approval from the California Department of Fish and Game may be required for the appropriation of water to verify that the loss of water will not have an adverse effect on fish and wildlife resources.

Finally, storage of water during non-peak demand periods may involve regulations from the Division of Safety of Dams, Monterey County Environmental Health & Planning Department, and the CCRWQCB depending on storage location and water quality.

3.2. Task 3: Development of Work Plans

The following plans for performing pilot studies were developed during the report period:

- Sample Analyses Plan
- Pilot Work Plan
- Health and Safety Plan

All the three plans are presented in Appendix B, C and D.

Section 4: Proposed Work For The Next Quarter

It is anticipated that activities related to performing the pilot study will be initiated during the next quarter. However, an approval from DOE for performing the phase II work is required prior to initiating these tasks. Contingent upon DOE's approval the following tasks will be performed during the next quarter.

4.1 End User Outreach

To date contact with the end users who have expressed interest has been through email, phone, and letters. Face-to-face meetings with the potential users will be held to describe the project in more detail and gather concerns and identify particular issues for each of the entities that have expressed interest in the water.

4.2 Development of Engineering Drawings

During this quarter Kennedy/Jenks will work with Aera Energy LLC's engineering contractor (DCCK Engineering) to develop engineering drawings for installation of pilot units and accessories.

4.3 Performance of Pilot Study

Upon receiving approval from DOE and Aera Energy LLC, the following activities will be performed towards the pilot study:

- Site preparation
- Vendor Selection
- Pilot Equipment Installation

References

1) California. State Water Resources Control Board. Division of Water Rights. *Information pertaining to water rights in California*. Sacramento, CA: State Water Resources Control Board, 2000.

2) California. State Water Resources Control Board. Division of Water Rights. *How to file an application to appropriate water in California*. Sacramento, CA: State Water Resources Control Board, 2000.

3) California. State Water Resources Control Board. Division of Water Rights. *A Guide to California water rights appropriations*. Sacramento, CA: 2001

List of Acronyms and Abbreviations

AG	Agricultural Water Supply
CCRWQCB	Central Coast Regional Water Quality Control Board
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CTR	California Toxics Rule
DOE	Department of Energy
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
IND	Industrial Water Supply
MCWRA	Monterey County Water Resources Agency
MUN	Municipal and Domestic Water Supply
NPDES	National Pollutant Discharge Elimination System
NTR	National Toxics Rule
QA/QC	Quality Assurance/Quality Control
SCWD	Santa Cruz Water Department
TDS	Total Dissolved Salts
USFWS	US Fish & Wildlife Services
WDR	Waste Discharge Requirements

From: Johnson, Robert [johnsonr@co.monterey.ca.us]
Sent: Friday, September 05, 2003 11:38 AM
To: 'Ganesh Rajagopalan'
Cc: 'LarryLeong@KennedyJenks.com'; Weeks, Curtis Ext.4896; Phillips, Bill x5159; Lampo, Rose Ext.4896; Franklin, Howard Ext.8902; Thomasberg, Kathy Ext.4963
Subject: RE: Produced Water from Aera Energy, LLC - Beneficial Reuse

Dear Ganesh:

Thank you for your letter describing the background of this project. It was very helpful to review the progress Aera has made in accordance to this project. As per our phone conversation on September 5, 2003 you indicated that the DOE has provided a grant that is phased over two fiscal years to research and fund a pilot project. The Agency is aware of the time constraints related to the provision of financial resources for the remainder of this Federal fiscal year (Year One of the project).

Overall, the Agency is supportive of projects that can increase the beneficial uses of water in the Salinas Valley and Monterey County. At this time it seems the Agency would be premature in offering a position in regards to supporting or denying a project of this type until a pilot project is completed and the data analyzed and evaluated by not only the consultants but Agency staff also.

Since the Agency is supportive of projects that can provide increased uses of the Salinas Valley water resources, we are supportive of the implementation of the pilot project mentioned in the attachment to the previous e-mail. Please understand that we are a long way from implementation of a full project, considering permitting requirements and the location of possible recipients of the treated water, however at this time we support you moving forward with the pilot project so data can be gathered and evaluated.

Please feel free to call me to discuss other issues related to this project, as well as the progress of the pilot project.

Sincerely,
Robert Johnson

Robert Johnson
Chief of Water Resources Planning
Monterey County Water Resources Agency
893 Blanco Circle
Salinas, CA 93901
Phone: (831) 755-4860
FAX: (831) 424-7935
Email: johnsonr@co.monterey.ca.us
Jer. 29:11

-----Original Message-----
From: Ganesh Rajagopalan [mailto:RGanesh@KennedyJenks.com]
Sent: Friday, August 22, 2003 2:12 PM
To: 'johnsonr@co.monterey.ca.us'
Subject: Produced Water from Aera Energy, LLC - Beneficial Reuse

Dear Mr. Johnson:
This is in response to our earlier discussion on the potential water trade involving treated oil field produced water from Aera Energy, LLC at San Ardo. As desired by you I have enclosed a description of the project

indicating quantity, quality and long-term availability of the water. During a meeting on 8/20/03, Aera officials indicated that a decision on the cost scenario for the use of treated water has not been made yet.

Once you had an opportunity to review this memo, I would like to meet with you to discuss any concerns you may have regarding this issue. Central Coast RWQCB has provided us the water quality criteria for the treated water for delivery/use through Salinas River. We are planning to initiate a nine-month long pilot study later this year to obtain performance data to evaluate compliance with regional board requirements.

Please feel free to call me at (949) 261 1577 or send e-mail to rganesh@kennedyjenks.com, if you need more information.

Thank you

Ganesh Rajagopalan, Ph.D.
Advanced Technologies Group
Kennedy/Jenks Consultants
2151 Michelson Drive, Suite 100
Irvine, CA - 92612
Phone: (949) 261 1577
Fax: (949) 261 2134
E-mail: rganesh@kennedyjenks.com

Appendix A2 - Santa Cruz WD (8-28-03)

From: BKocher@ci.santa-cruz.ca.us
Sent: Thursday, August 28, 2003 4:08 PM
To: RGanesh@KennedyJenks.com
Subject: Water Reuse project

Ganesh, thank you for sharing your water reuse proposal with me. I am intrigued by the project and would encourage you to continue your investigations. You have touched on exactly the issues of concern to a potential buyer, i.e. water quality, permitting, cost, required infrastructure. It's too bad that the power plant is too far away to offer an economical solution as once-through cooling with other potable water sources is falling into great disfavor.

The City of Santa Cruz is not a close enough neighbor to your project to consider it, though I wish that were not true, as we are currently pursuing seawater desalination that will cost about $1500-$1800 per acre foot. At over $100 per foot of pipeline, the cost for this relatively small amount of water simply cannot be justified unless it could be delivered via a water trade or other some such wheeling.

Much closer to you, in the Salinas Valley, wells in the proximity of the coast are experiencing seawter intrusion and the problem is worsening. Replacement water and a coastal distribution system would seem to be the only way short of fallowing the land that this groundwater contamination can be halted. Most of northern Monterey County and South Santa Cruz County is in water crisis with the overwhelming majority of water used for agriculture. Assuming you have a project that can be permitted, can produce water that is affordable for farming to at least the extent of current pumped water, is of a quality that it is usable for overhead irrigation, can be transported cheaply (like via the Salinas River), and is sustainable for the near future, I think you have a winner.

I will be following your reuse proposal with great interest as another option in the overall water supply portfolio is always eagerly embraced by the professional water community.

Bill Kocher, Director, Santa Cruz Water
bkocher@ci.santa-cruz.ca.us

Appendix B

Kennedy/Jenks Consultants

2151 Michelson Drive, Suite 100
Irvine, California 92612-1311
949-261-1577
949-261-2134 (Fax)

Work Plan

San Ardo Oilfield
San Ardo, California

For

Cooperative Agreement No: DE-FC26-02NT15463

Recovery of More Oil-in-Place at Lower Production Costs while Creating a Beneficial Water Resource

17 October 2003

Prepared for

Aera Energy LLC
10000 Ming Avenue
Bakersfield, CA 93389

K/J Project No. 024033.00

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Section 1: Introduction

This work plan is intended to provide information for the pilot system to treat produced water from Aera Energy LLC's San Ardo Oilfield. This work plan provides a description of the pilot system, the intended objectives of testing, target operating conditions to be evaluated, the anticipated test schedule, and information pertaining to installation and demobilization of the pilot system.

1.1 Background

Aera Energy LLC leases and operates an oil production field in the region in and around San Ardo, California. The oil production process there entails steam flooding the geologic formation to reduce the viscosity of the crude oil so that it can be pumped to the surface. As is the case for many mature oil production well fields, the liquid pumped from the formation contains a large amount of water (produced water) with the crude oil. In many instances, up to 15 barrels of produced water can be produced for every barrel of oil. Once brought to the surface, the oil is recovered and the produced water is pumped back into the formation through the use of deep well injection.

Such on-field injection may increase the produced water to oil ratio and reservoir pressure resulting in higher oil production costs. A potential alternative to the current operating practice would entail treatment of the water so that it could be put to beneficial reuse. Reducing Class II injection through beneficial reuse of treated produced water can optimize oil production and increase recoverable reserves in an oilfield. Recognizing that these potential benefits to water reuse exist, Aera Energy LLC has agreed to participate in a pilot investigation with Kennedy/Jenks Consultants (Kennedy/Jenks) along with funding from the U.S Department of Energy (DOE) to determine if pursuing treatment on a full-scale basis is warranted.

This pilot investigation will look into the treatment of the produced water through the following three-stage process:

- Warm precipitative clarification to remove hardness, carbonate alkalinity, and silica;
- Cooling through the use of a cooling tower to remove excess heat energy and to possibly strip ammonia; and
- Reverse osmosis (RO) to remove boron, ammonia, total organic carbon (TOC), and total dissolved solids (TDS).

Kennedy/Jenks has previously investigated this treatment process at other oil fields and viewed it to be the most suitable process to evaluate treatment of the produced water at San Ardo.

1.2 Objectives

The pilot investigation at San Ardo will seek to meet the following objectives:

- Determine the optimum range of operating conditions in the precipitative clarification process to remove hardness, carbonate alkalinity, and silica.

- Determine the best chemical additive(s) for use in the precipitative clarification process.

- Estimate the sludge generation rate for the precipitative clarification process and develop a characterization of the sludge.

- Determine the capacity of the cooling tower to remove ammonia via air stripping

- Determine the optimum range of operating conditions in the RO process to remove boron, ammonia, and TOC.

- Estimate the cleaning requirements and lifespan of the RO membranes.

- Determine the chemical consumption rates for the RO process for both operation and cleaning.

- Determine the impact of environmental factors on the entire process through the operating period (estimated to be 8 months over a 9 month period).

- Based on the findings of the pilot test, develop planning level estimates of the capital and operations and maintenance (O&M) costs for a full-scale facility at San Ardo. These estimates will include cost scenarios for treatment to meet California Department of Health Services (DHS) requirements for groundwater recharge as well as treatment to meet California Regional Water Quality Control Board (RWQCB) requirements for irrigation use.

1.3 Pilot Schedule

The pilot program will be performed in two Phases (IIA and IIB), each over a period of four months. It is anticipated that Phase 2A study will be performed from January ’04 to April ’04. The data from this study will be evaluated in May ’04 and used to refine the work plan for Phase 2B study. Phase 2B will be performed from June 04 to September 04.

1.4 Organization of the Work Plan

Section 1 of the work plan provides the background, objectives of the pilot study. Section 2 provides the details of pilot system, components and operating conditions. Section 3 provides installation and demobilization schedule and Aera Energy LLC and Kennedy/Jenks roles and responsibilities. Section 4 provides details of test schedule, system operations, equipment calibration and adjustment.

Section 2: Pilot System and Components

The pilot system will treat a 30 gpm stream of produced water taken from one of the pipelines that currently returns produced water from the San Ardo field to the existing deep well injection process. The system will consist of 3 main treatment components, with each component designed to remove specific constituents from the produced water. They include a warm precipitative softening unit, followed by a cooling tower, and finally an RO process. Figure 2-1 shows a schematic process flow diagram for the pilot study. The produced water is first introduced to the precipitative softener unit at approximately 190°F. This unit will remove primarily hardness (calcium and magnesium), alkalinity (as carbonate), and silica, and will function secondarily to remove some of the boron in the water. The cooling tower is intended to reduce the temperature from the 190°F range to less than 115°F to protect the RO membranes. The cooling tower will also be evaluated for potential removal of the ammonia and carbon dioxide present in the water via air stripping. The RO unit will remove the bulk of the dissolved solids (TDS), organic compounds, residual hydrocarbons, and boron from the water.

This section provides details on each of the treatment components of the pilot system including a description of each unit and how it functions, its treatment mechanism(s), the normal operating conditions for the unit, and information on any ancillary systems associated with the unit.

2.1 Precipitative Softening

Precipitative softening is a process designed primarily to remove hardness (calcium and magnesium), carbonate alkalinity, and silica. It functions on the principle that these constituents can be precipitated out as insoluble salts. The process generally consists of two steps, with the first involving raising the pH of the feed water through the addition of either caustic soda (sodium hydroxide) or dolomitic lime (lime). Once the pH is raised, the hardness and alkalinity constituents precipitate mainly as calcium carbonate, magnesium hydroxide, and magnesium carbonate. Silica is simultaneously removed from the feed water through precipitation as magnesium silicate and through silica adsorption onto precipitated magnesium hydroxide. The second step in the process involves separating the solids from the treated water. Separation is typically accomplished through the use of an upflow clarification step, in which the water and solids are introduced to the bottom of the clarification vessel and flow upwards at a relatively low loading rate. Because of their mass, the solids slowly settle to the bottom as the treated water flows over a weir at the top of the unit. The solids, which form a sludge as they settle, are removed from the unit through a periodic or continuous blowdown. A polymer is typically added to increase the weight percent of solids in the blowdown sludge.

2.1.1 Unit Description

The unit to be used in the pilot test is a ClariCone precipitative softening unit, manufactured by CBI Walker, Plainfield, IL. It consists of a conical steel vessel, with a 2-ft diameter base that expands to 8-ft at the top. The total height of the unit is 12-ft, 8-in, and it occupies a footprint of 7.5-ft by 12-ft. Figures 2-2 and 2-3 show the plan and elevation views of the unit. The feed water is introduced at the base of the unit at up to a flow rate of 30 gpm. Caustic, lime, and/or polymer are also introduced at this location. After a short mixing, the treated water and precipitated solids begin flowing upwards through the unit. Because of the conical design of the vessel, the upflow velocity of the water decreases as it moves upwards through the unit. The

decreasing velocity helps prevent the smaller precipitated particles from being carried over to the cooling tower. The solids are captured in the collection funnels located near the center of the unit and are removed via continuous blowdown. The clarified water spills over a weir into a collection box, which then conveys the water to the cooling tower.

2.1.2 Operating Conditions

The ClariCone unit is designed to handle the feed water at temperatures up to 190°F at atmospheric pressure. It is designed to treat a continuous feed water flow rate of 30 gpm supplied by a separate feed pump.

2.1.3 Chemical Feeds

Four chemicals will be used in the warm softening process to remove hardness, alkalinity, and silica. They are:

- Caustic soda (sodium hydroxide). Technical grade caustic is the cleanest chemical that can be used for this process. The higher cost of caustic soda over hydrated lime, and the increase in sodium levels in the softened water may pose limitations on the potential use of this chemical for warm softening.

- Lime. This chemical is often preferred over caustic soda because it is less expensive and supplements the magnesium concentration to assist in the silica removal. Due to its lower solubility, hydrated lime is often used as a slurry in the treatment process. The chemical will be supplied as slurry by the vendor. Although less expensive than caustic, use of lime requires substantially more operator attention than caustic because it is prone to frequent plugging and clogging in conveyance and chemical feed systems.

- Magnesium. This chemical is used in conjunction with either caustic soda or hydrated lime to increase the precipitation of silica as magnesium silicate. This chemical will be added directly as magnesium chloride solution or through the use of dolomitic lime, depending on cost and availability.

- Anionic polymer. This chemical will be added to increase the settleability of the sludge solids. Jar tests may be performed as needed to determine the optimum dosing rate range.

The chemicals will be stored separately in a storage container and will have individual metering pumps and feed systems. Caustic soda, lime and magnesium chloride storage and feed systems will be housed in secondary containment.

2.1.4 Solids Management

The solids generated in the process will consist mostly of calcium carbonate, magnesium carbonate, and magnesium hydroxide with smaller quantities of magnesium silicate, calcium sulfate, and borate salts. Based on this makeup, the solids from the process are not anticipated to be classified as a hazardous material. The solids will be separated from the water as a sludge in a blowdown stream and are anticipated to be anywhere from 2 percent to 20 percent solids by weight, depending on the chemicals added at the front end of the unit. The sludge blowdown will be captured in a watertight mud tank. Once in the tank, the sludge will be allowed stand so that the solids can further settle from the water. The excess water will be

decanted from the mud tank and returned to the San Ardo produced water conveyance system. The settled solids will be removed for offsite disposal.

2.2 Cooling Tower

It is anticipated that the temperature of the softened water from the clarifier will be about 190°F. Cooling this water below 115°F is essential to protect the RO membranes. Cooling could be achieved through the use of either a heat exchanger or cooling tower. The cooling tower option was chosen for the pilot system due to the potential to strip the ammonia from the water.

2.2.1 Unit Description

The cooling process consists of two components: an equalization tank that captures the effluent from the precipitative softener, followed by the cooling tower. The equalization tank is a 6,500 gallon tank with a fixed overflow nozzle and a suction discharge at the base of the tank. The overflow drains the excess flow volume from the precipitative softener to the pilot system waste line. This configuration allows the tank to maintain a fixed water level and a fixed amount of total dynamic head for the feed pump to the cooling tower.

The cooling tower to be used in the pilot system is a 55-inch diameter by 111-inch tall single-pass unit. It is a countercurrent design with an approximate 56-inch depth of packing material and provides up to 25 tons of cooling. Effluent from the precipitative softener is fed to the cooling tower through a 2-½ -inch inlet at the base of the unit. Air to cool the water is provided through a ¾ HP blower. The cooled water, collected in a sump, is pumped to the membrane treatment process via a 2 ½-inch outlet at the base of the cooling tower. Schematics of the cooling tower will be included upon receipt from the vendor.

2.2.2 Operating Conditions

The equalization tank is expected to capture a 30 gpm effluent stream from the precipitative softener. 25 gpm is expected to flow through the cooling tower, with the 5 gpm balance to spill into the overflow line. The cooling tower is designed to reduce the water temperature from 190°F to 115°F at a flow rate of up to 50 gpm. Since the unit is oversized, it should be able to achieve the same temperature reduction for the anticipated 25 gpm stream.

2.3 Reverse Osmosis (RO)

RO functions on the principle that water can be separated from colloidal material and/or dissolved constituents by forcing the water through a semi-permeable membrane. In a typical operation, the untreated water is introduced on the feed side of the membrane where it is subjected to high pressure. Once the pressure of the feed water is increased beyond the osmotic pressure of the membrane, water will begin to pass or “filter” through leaving behind the colloidal material and/or dissolved constituents. The materials originally present in the feed are then left to concentrate in the remaining water on the feed side of the membrane. The water that passes through the membrane, or permeate, is collected as treated water. The water remaining on the feed side of the membrane, containing the now concentrated colloidal and dissolved constituents, is disposed of as brine.

This pilot system will utilize RO membranes as the primary treatment mechanism to remove boron, ammonia, organic compounds and TDS. Other membrane types, such as nanofiltration

or ultrafiltration membranes, may also potentially be evaluated depending on the findings from the initial test runs with RO.

2.3.1 Unit Description

The pilot RO unit to be used in the pilot will be a VINTAGE™ V series system (VC06) from US Filter. The system consists of a 5 micron cartridge filter, six 4"X40" brackish water spiral bound membrane housed in six pressure vessels arranged in a five stage (2:1:1:1:1) array, a submersible pump, and a recycle line to return a portion of the reject stream into the incoming feed. The dimensions of RO unit are 72"(H)X38"(W)X34"(L). The unit requires a 480V power supply. The membranes to be used will be Fluid Systems XR "extra high rejection" polyamide membranes. Table 2-1 provides the design criteria for the system. Figure 2-3 shows the schematic and process flow diagram for the RO process.

2.3.2 Operating Conditions

The RO unit will be operated with 75 percent water recovery. At a feed rate of 10 gpm, the RO unit will produce about 7.5 gpm of permeate and 2.5 gpm of RO concentrate (brine). The flux rate would be about 25 gpd/sf of membrane area. The feed water pressure at the suction side of the booster pump must be between 15 and 25 psig. The unit will be operated approximately at a feed pressure of about 320 psig.

2.3.3 Chemical Feeds

PreTreat Plus 0100, an inorganic scale inhibitor/antifoulant manufactured by King Lee Technologies, will be added to the RO feed water during all test runs at a rate of 1 mg dry powder/L feed water to reduce the prospect for inorganic fouling. During pH < 9.6 and all following trials, Protec RO, an organic antifoulant manufactured by King Lee Technologies, will also be added to the RO feed water at a rate of 5 mg dry powder/L feed water to minimize potential residual oil fouling. Cleaning will be performed using DIAMITE AFT manufactured by King Lee Technologies when either a pressure drop of 20 percent is observed between stages or a 20 percent pressure increase is observed across the membrane at the inlet to the first stage. Ninety gallons of cleaner will be made by diluting 1 part concentrated cleaning solution to 40 parts water. For each cleaning, the solution will be circulated through the RO unit at 20 gpm and 60 psi for 1 hour.

2.3.4 Clean In Place

USFilter CIP-30 Clean-in-place system (CIP) will be used for cleaning the RO unit. This unit consists of a solution tank (90 gallons), centrifugal recirculation pump (30 gpm, 70 psig, 5 HP) and a filter housing. The overall dimensions of the unit are 72”(L)X41”(W)X41”(H). During the cleaning cycle, the RO unit will be taken offline and the valving reconfigured so that the CIP system can pump cleaning solution through the RO in a closed recirculation loop.

TABLE 2-1
Design Parameters for RO Process During Phase 2A Study
Aera Energy LLC-DOE Produced Water Pilot Study

Design Parameter	Units	Value
Cartridge Filter		
Number of Units		1
Feed Rate	Gpm	10
Filter Rating	µM	5
Size (diameter x length)	Inch x inch	2.5” x 10”
RO		USFilter Membrane Systems
Number of Stages		5
Number of Vessels		6
Elements per Vessel		1
Membrane Elements		Fluid Systems XR
Number of Elements	-	6
Size (diameter x length)	inch x inch	4 x 40
Effective Surface Area	Sf/Element	72
Flux Rate	gpd/sf	15.7
Permeate Flow Rate	Gpm	7.5
RO Concentrate Flow Rate	Gpm	2.5
Percent water recovery	%	75
Feed Pressure	Psi	350

Cleaning will be performed using DIAMITE AFT manufactured by King Lee Technologies when either a pressure drop of 20 percent is observed between stages or a 20 percent pressure increase is observed across the membrane at the inlet to the first stage. In addition, the RO unit will be purged through a cleaning cycle prior to changing test conditions. Ninety gallons of cleaner will be made by diluting 1 part concentrated cleaning solution to 40 parts water. For each cleaning, the solution will be circulated through the RO unit at 7 gpm and 60 psi for 1 hour.

Section 3: Installation and Demobilization

Installation is anticipated to take two to four weeks, depending on the arrival of vendor rented equipment, availability of contract construction personnel, and availability of facilities/equipment supplied by Aera Energy LLC. Delineation of responsibilities during installation is as follows:

- Aera Energy LLC will provide utilities (potable water as available, power, disposal facilities for sludge and spent chemicals, etc), large storage tankage for chemicals, and secondary containment for chemical storage.
- Aera Energy LLC will supply contract personnel and construction equipment for system construction.
- Aera Energy LLC will supply all piping, meters, gauges, valves, and associated fitting necessary for construction of the pilot system.
- Kennedy/Jenks will supply construction oversight.
- Kennedy/Jenks will supply chemical feed equipment, chemical storage tanks not available through Aera Energy LLC, and chemicals.
- Kennedy/Jenks will subcontract equipment vendors for rental of pilot units.

Demobilization is anticipated to take two weeks. Delineation of responsibilities during demobilization is as follows:

- Aera Energy LLC will supply contract personnel and construction equipment for system disassembly.
- Aera Energy LLC will dispose of all residual materials from the pilot system (pipes, fittings, etc.)
- Kennedy/Jenks will coordinate disposal of all residual chemicals at the end of the pilot test.
- Kennedy/Jenks will supply field oversight during demobilization activities.
- Kennedy/Jenks will coordinate with vendors for return shipping of rental pilot units.

Section 4: Test Schedule and System Operations

4.1 Test Schedule

The pilot investigation is scheduled to run for a 9-month test period during which a number of operating conditions will be evaluated. Because the later stages of testing will depend on the findings of the initial test runs, the pilot investigation has been divided into two phases (2A & 2B). The first phase (2A) will run for four months and is intended to establish the optimum baseline conditions for the various chemicals that are to be evaluated. Table 4-1 summarizes the test conditions during the initial four-month operating period.

TABLE 4-1
Phase 2A Tests
Aera Energy LLC-DOE Produced Water Pilot Study

Week	Precipitative Clarifier Chemical(s) Added	Target Effluent pH	Reverse Osmosis Target Feed pH
1	Caustic Soda	9.7	9.7
2	Caustic Soda	9.7	9.7
3	Caustic Soda	9.7	9.7
4	Caustic Soda Magnesium Chloride	9.7	9.7
5	Caustic Soda Magnesium Chloride	9.7	9.7
6	Caustic Soda Magnesium Chloride	9.7	9.7
7	Caustic Soda Magnesium Chloride	9.7	10.75
8	Caustic Soda Magnesium Chloride	9.7	10.75
9	Caustic Soda Magnesium Chloride	9.7	11
10	Caustic Soda Magnesium Chloride	9.7	11
11	Dolomitic lime	9.7	9.7
12	Dolomitic lime	9.7	9.7
13	Dolomitic lime	9.7	9.7
14	Dolomitic lime	9.7	9.7
15	Dolomitic lime	9.7	9.7
16	Dolomitic lime	9.7	9.7

The scope and schedule of Phase 2B will be defined based on the results from Phase 2A study. However, the tentative scope of the work and schedule (Table 4-2) during this phase are provided below:

- Evaluation of a biocatalyst/surfactant system developed by Advanced Biocatalytics Corporation, Irvine, CA for the cleaning of RO membrane to enhance membrane life. The catalyst may be added continuously or at the end of each cycle.

- Evaluation of a membrane developed by Osmonics (DS-3) to compare with the performance of USFIlter XR membrane. This duraslick thin film element is designed to treat high fouling brackish waters. Membrane life and effectiveness of treating oil field produced water of this membrane will be compared with those of the USFilter DX membrane.

- Evaluation of warm precipitation using spent caustic from refinery operations using bench scale studies

TABLE 4-2
Phase 2B Tests
Aera Energy LLC-DOE Produced Water Pilot Study

Week	Precipitative Clarifier Chemical(s) Added	Target Clarifier Effluent pH	Reverse Osmosis Target Feed pH	Comments
1	Caustic Soda	9.7	9.7	Continuous Biocatalyst Feed
2	Caustic Soda	9.7	9.7	Continuous Biocatalyst Feed
3	Caustic Soda	9.7	9.7	Continuous Biocatalyst Feed
4	Caustic Soda	9.7	9.7	Biocatalyst cleaning at the end
5	Caustic Soda	9.7	9.7	Biocatalyst cleaning at the end
6	Caustic Soda	9.7	9.7	Biocatalyst cleaning at the end
7	Caustic Soda	9.7	9.7	Osmonics DS-3 Membrane[1]
8	Caustic Soda	9.7	9.7	Osmonics DS-3 Membrane
9	Caustic Soda	9.7	9.7	Osmonics DS-3 Membrane
10	Dolomitic lime	9.7	9.7	Osmonics DS-3 Membrane
11	Dolomitic lime	9.7	9.7	Osmonics DS-3 Membrane
12	Dolomitic lime	9.7	11	Osmonics DS-3 Membrane
13	Dolomitic lime	9.7	11	Osmonics DS-3 Membrane
14	Dolomitic lime	9.7	11	Osmonics DS-3 Membrane
15	Dolomitic lime	9.7	11	Osmonics DS-3 Membrane
16	Dolomitic lime	9.7	11	Osmonics DS-3 Membrane

4.2 System Monitoring

The Kennedy/Jenks staff will operate the pilot treatment units during business week days. During the evenings and on weekends, when there is no demonstration staff at the site, Aera staff will respond to any alarms and shut the plant down. Demonstration plant staff will fix the problems and restart the plant the following weekday except on Friday. If it is a Friday, the plant will be restarted the following Monday for routine operations.. Operators will use log sheets to record pilot plant

operating data. Kennedy/Jenks staff will also perform field water quality analyses and collect samples for outside laboratory analyses, consistent with the Sampling and Analysis Plan.

4.2.1 Warm Softening Process

Log sheets will be set up to record produced water flow rate to the clarifier, effluent recirculation flow rate, and net operating flow rate through each of the unit inlets. We will monitor these parameters, adjust the flow meters to the target rate as necessary, and record the results every 3 hours until we get operating history on the unit. We will also record the frequency and duration of the automatic sludge blowdown. We should also make a visual inspection of the unit and the sludge blanket from the bridge at least twice a day.

4.2.2 Cooling Tower

Log sheets will be set up to record flow rates to the influent and temperature at the influent and effluent of the cooling tower. Operating staff should monitor and record the readings every three hours.

4.2.3 RO Process

Log sheets will be set up to record flow rates (RO feed, permeate, and RO concentrate), pressures (cartridge filter feed, post cartridge filter, boosted RO feed, permeate – as provided by vendor). Staff should monitor these instruments and record these values once every 3-hours. Staff should also record temperature, pH, and electrical conductivity from the meters provided on the units at least daily.

4.2.4 Chemical Feed Systems

The operators need to determine the chemical feed rate for each chemical fed to each process unit so that the chemical dosage being used is documented. During the each monitoring round performed by the operator, data on the chemical feed rate (ml/min) to each process unit will be recorded on the log sheet. Additionally, the chemical feeds will be adjusted if the dosing rate is observed to have drifted from the dosing target.

4.3 Equipment Calibration/Adjustment

The pilot plant is not automated and most of the treatment processes will require periodic adjustment or calibration of key flow rates, operating pressures, chemical feed rates, and residuals production rates. Each of these items for each process unit is addressed below.

4.3.1 Pressure/Flow Rate Adjustment

The sections below address the requirements to adjust the pressure and flow for each treatment processes in the pilot system.

4.3.1.1 Warm Softening Process

Produced water from the walnut shell filter is discharged to a 6,500 gallon storage tank, which supplies the feed for the warm softening process. The produced water is pumped from the tank

to the clarifier unit with a centrifugal pump. The pump is controlled via start/stop pushbuttons mounted locally on panel adjacent to the pump. Flow from the tank to the clarifier unit is controlled with a 2" butterfly valve located just downstream of the pump and a 0 – 50 gpm rotameter. Downstream of the valve and rotameter, the produced water feed is combined with a recirculation stream that reintroduces treated effluent from the process back to the influent of the unit. A separate centrifugal pump is used to recirculate the treated effluent back to the influent and is controlled with locally mounted on/off pushbuttons. The recirculation flow is controlled through the use of a 1" ball valve and a 0 – 20 gpm rotameter, both located on the discharge line of the recirculation pump. The combined influent is introduced at the base of the clarifier unit through two pairs of tangentially oriented inlet pipes (four total). Flow through each pipe is controlled with a ball valve. A 0 – 30 gpm rotameter is located upstream of each pair of inlet pipes to indicate the flow.

To adjust the flow into the clarifier unit, the produced water feed is first set. Then, the recirculation flow rate is adjusted. Once these flows are set, the combined influent is balanced between the two pairs of inlet pipes at the base of the clarifier unit. The clarifier unit does not operate under pressure (water level controlled by an overflow weir) and, consequently, does not have any controls for pressure.

4.3.1.2 RO Unit

In the RO operating configuration, the feed water is supplied to an RO booster pump that, in turn, increases the pressure to the level required for the membrane process to achieve the desired recovery. As part of such a configuration, the operating criteria specified by the RO vendor must be maintained. These include the following:

- Raw Water Supply Pressure – The pressure on the suction side to the RO booster pump must be maintained between 15 and 50 psig. A pressure gauge for this purpose is located just upstream of the RO booster pump.

- RO Feed Water Temperature – The total feed temperature to the RO must not exceed 113^{o}F.

- RO Feed Water Temperature - The total feed flow must be maintained approximately at 10 gpm. Flow meters for the permeate and concentrate lines are used to determine the total flow through the unit.

While maintaining these operating requirements, the RO unit must also be maintained at the target recovery for the pilot test period. The following valves are used to balance these three operating parameters:

- Concentrate Control Valve – This valve is located on the concentrate line of the RO skid and is used to set the recovery of the unit.

- Influent Water Throttling Valve – This gate valve is located on discharge pipe from the warm softening unit. It is intended to provide control over the total flow output from the softener.

- Softened Water Bleed-off Valve – This gate valve controls the volume of water from softener unit that is allowed to discharge directly to the waste discharge line as excess flow. This valve is used to help control the feed pressure to the RO unit on the suction side of the RO booster pump.

- RO Booster Pump Throttling Valve – This gate valve is located immediately downstream of the RO booster pump and is used to control the membrane feed pressure and total feed water flow through the RO unit.

Adjustments to any of these valves may impact the feed pressure to the RO booster pump, the total feed flow to the RO unit, and the recovery to shift. Therefore, adjustments to maintain the RO at the desired operating conditions will generally require balancing of all four valves.

4.3.2 Chemical Feed Systems

This section lists the chemical feeds and the chemical feed pump types used for each treatment process. Note that Section 4.3.3 immediately following this section provides the procedure to adjust the chemical feed rates.

- Reverse Osmosis:
  - Antiscalant (King Lee Pretreat Plus 0100) – diaphragm metering pump.
  - Antifoulant (King Lee Protec RO) - diaphragm metering pump.
  - Cleaning Solution (King Lee DIAMITE AFT) – USFilter CIP30 with centrifugal pump.
- Warm Softener:
  - Dolomitic Lime (45 percent hydroxide) – progressive cavity metering pump.
  - Caustic Soda (20 percent sodium hydroxide) – diaphragm metering pump.
  - Magnesium Chloride (27 percent solution) – diaphragm metering pump.
  - Chemtreat P-813E, (King Lee - a 35 percent by weight anionic polyacryamide polymer) - diaphragm metering pump

4.3.3 Chemical Feed System Adjustment

All chemical feed systems except the CIP are manually controlled and utilize calibration columns to make adjustments to the chemical dosing rates. The following is the procedure used to perform a chemical feed system calibration for any of the systems listed in Section 4.3.2:

1. Open the valve at the base of the calibration column while the chemical feed system is in operation. The column is located on the suction side of the chemical feed pump at an elevation near the base of the chemical storage tank. The static head provided by the chemical level in the tank will allow the column to fill.
2. Once the column fills above the “0 ml” mark, close the valve on the suction line that allows the chemical feed pump to draw chemical from the storage tank. The pump will begin drawing chemical from the calibration column.

3. When the liquid level in the column drops to the “0 ml” mark, observe the volume of chemical drawn down in 60 seconds. This is the actual dosing rate. Time is monitored with a stopwatch.

4. Open the valve on the pump suction line allowing the chemical feed pump to draw from the storage tank. Close the valve at the base of the calibration column. The chemical feed pump is now reconfigured for normal dosing operation.

5. If chemical is not being dosed at the target level, adjust the local speed and stroke controls (diaphragm metering pumps) or the local speed the speed control (peristaltic pumps). Repeat steps 1 – 4 until the target dosing rate is achieved.

4.3.4 Residuals

The unit processes will generate residual streams as part of their normal operation. They include the following:

- Warm Softening Process – Residuals from this process will include sludge, consisting mostly of calcium carbonate, calcium hydroxide, magnesium hydroxide, and magnesium carbonate. These materials are anticipated to be removed from the clarifier unit via a blowdown line as a 10 to 20 percent solids sludge stream. Sludge blowdowns will be controlled through a timer and a motorized valve. Sludge blowdowns will initially be set for 20 second durations at 90 minute intervals, per recommendations from the equipment manufacturer. The blowdown durations and frequencies will be adjusted as needed based on the findings of each test run.

- RO Process – The RO unit will be operated with 75 percent water recovery. At a feed rate of 10 gpm, the unit will generate a reject stream of 2.5 gpm. The reject stream will have a TDS of about 24,000 mg/l and a temperature of about 110^{o}F. A portion of the reject stream will be recirculated to the feed water stream to the RO process. The remaining flow will be discharged back into Aera Energy LLC produced water disposal system. The recirculation and waste stream flows are controlled by two ¾” throttling valves.

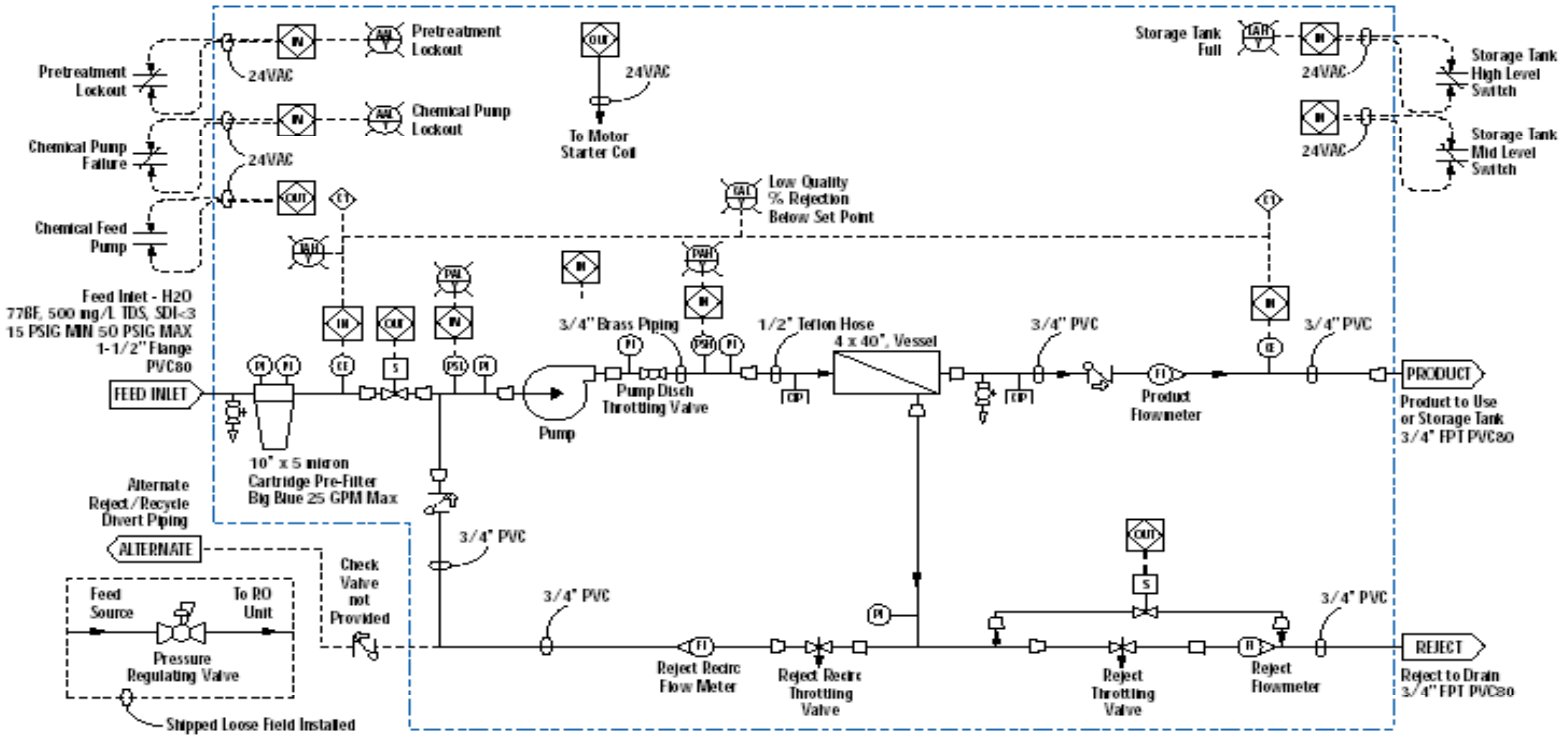

Figure 2-4. USFilter VANTAGE™ RO Process Flow Diagram

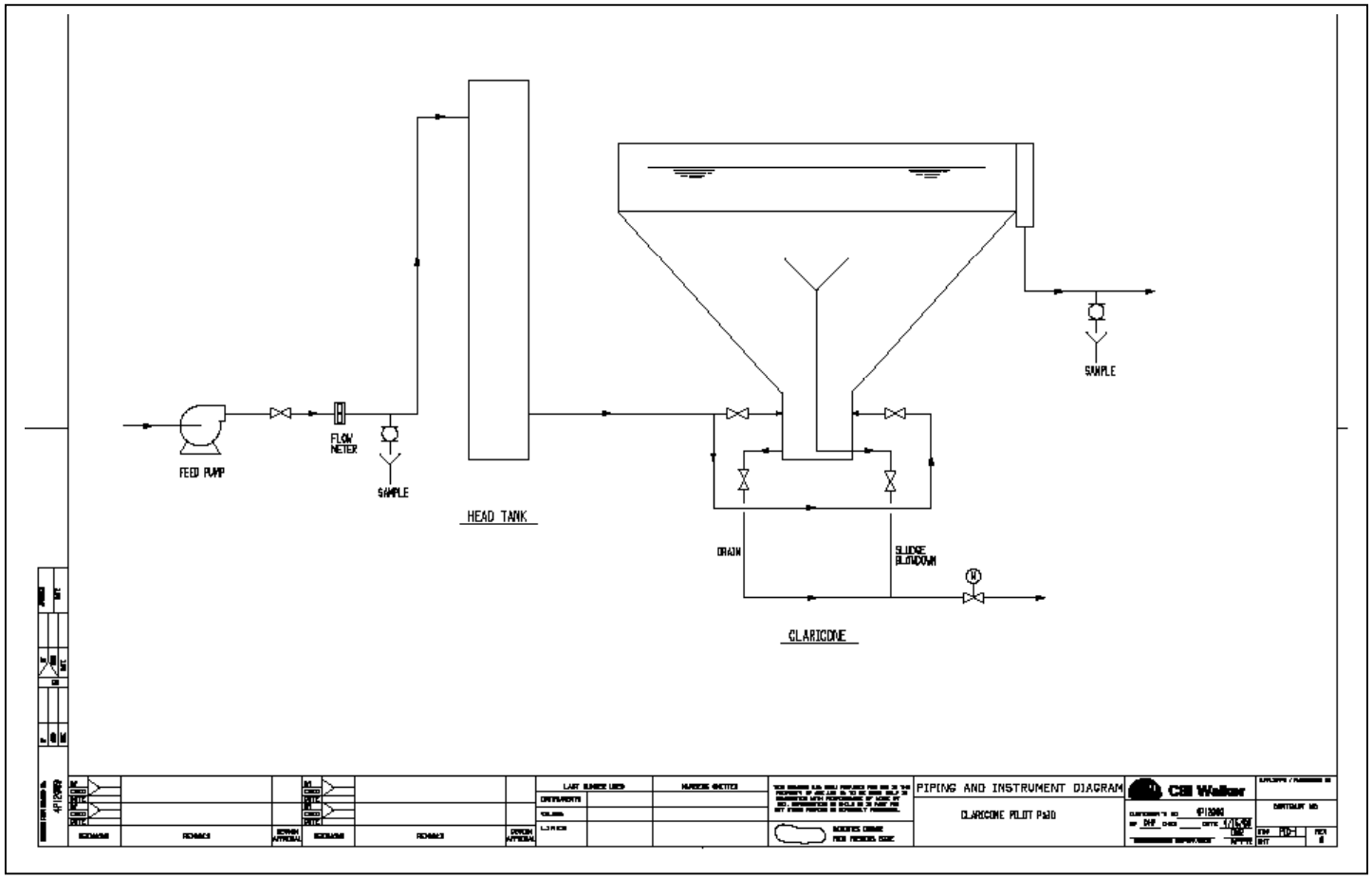

Figure 2-2. Elevation View of the CBI Walker Caricone Pilot Unit

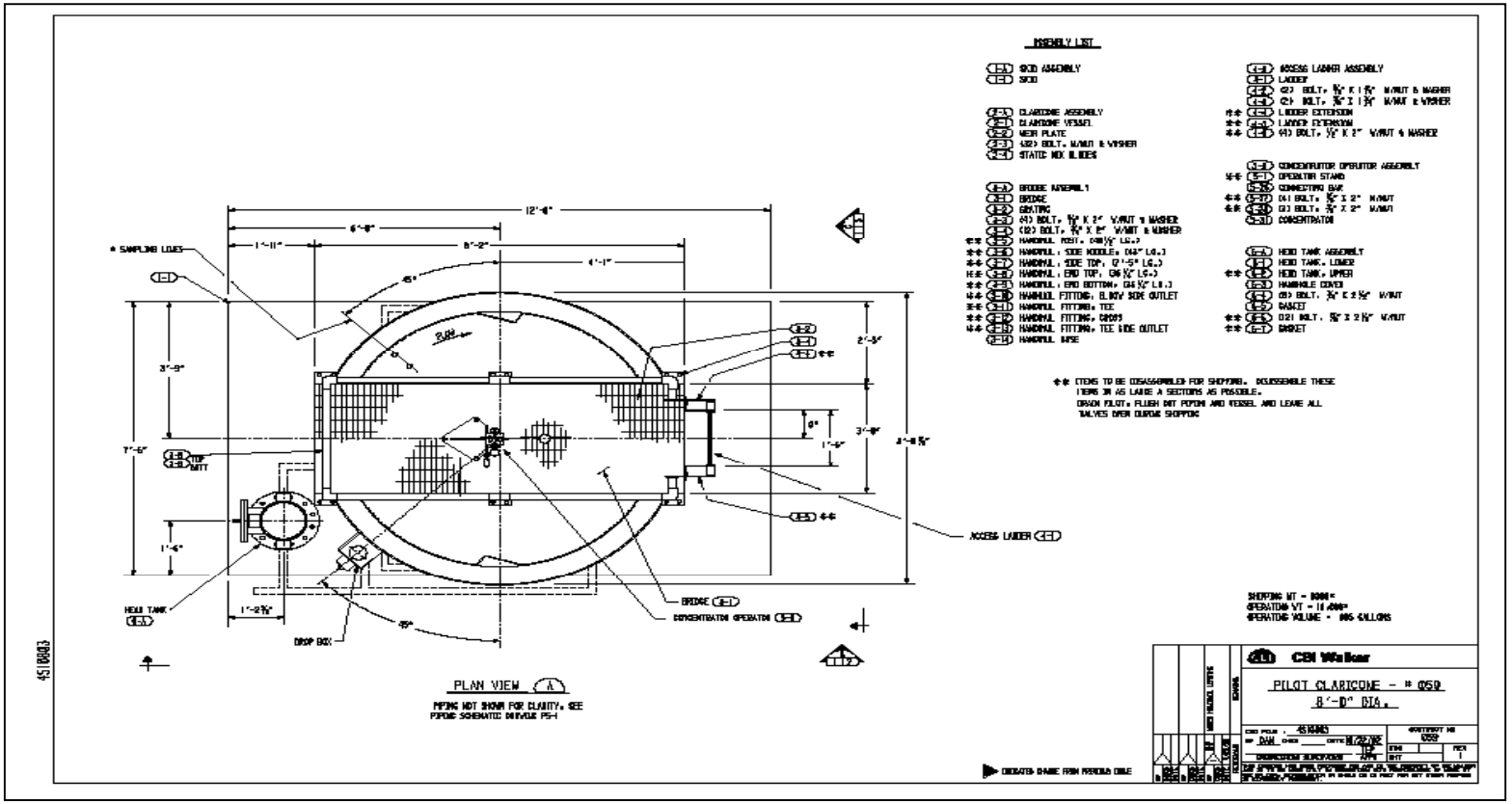

Figure 2-3. Plan view of the CBI walker ClariCone Unit

Appendix C

Kennedy/Jenks Consultants

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Sampling and Analysis Plan

San Ardo Oilfield

San Ardo, California

For

Cooperative Agreement No: DE-FC26-02NT15463

Recovery of More Oil-in-Place at Lower Production Costs while Creating a Beneficial Water Resource

17 October 2003

Prepared for

Aera Energy LLC
10000 Ming Avenue
Bakersfield, CA 93389

K/J Project No. 024033.00

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Section 1: Introduction

This document provides the Sampling and Analysis Plan (SAP) for the Aera Energy LLC Demonstration Plant located at the San Ardo Oilfield, Monterey County, California (66983 Seargent Canyon Rd, San Ardo, CA 93450). The SAP provides a guide for collecting, handling, and analyzing water quality samples during the demonstration study.

1.1 Background

Kennedy/Jenks Consultants will construct and operate a demonstration plant at the San Ardo Oilfield to assess treatment technologies for treating produced water generated during oil production. The goal of this project is to evaluate the potential of eliminating or reducing the volume of produced water reinjected into the formation following oil recovery activities. The benefits from eliminating the reinjection of produced water may be an increase the oil yield from the formation, reduction in energy costs associated with reheating the reinjected produced water, and providing an alternative source of potable water to nearby users.

The San Ardo Oilfield is located in Monterey County in central California, approximately 45 miles north of the city of San Luis Obispo. There are two oilfield operators in the San Ardo Oilfield, Aera Energy LLC and Chevron Texaco. Aera Energy LLC 's portion of the San Ardo Field covers an area of over 2,600 acres. The field consists of two main oil reservoirs, the Aurignac and the Lombardi. Both reservoirs are currently being produced using continuous steam injection. Field volumes for March 2002 were 8,294 barrels of oil per day, 44,015 barrels of steam per day, and 89,800 barrels of water disposal per day. Monterey County is the fifth largest crude oil producing county in California (Department of Conservation, 2001).

In order to stop Class II injection of the excess produced water, it is necessary to identify an appropriate alternative method for managing produced water. Alternatives include treatment for NPDES discharge into streams for groundwater recharge and/or treatment for beneficial use. This project is intended to show potential water users and regulatory agencies that produced water can be reliably treated to a quality acceptable for NPDES discharge, agricultural, or non-flange to flange municipal beneficial reuse.

After construction of the demonstration plant and system startup, it is estimated that the pilot study will be completed in two phases and be conducted over an eight month operating period to demonstrate that produced water can be treated to meet the following: 1) those criteria required by Aera Energy LLC; 2) those criteria required by the regulatory agencies; and 3) those criteria required by the end users of the treated water.

The first phase of operation will provide operational data on the technologies and operating procedures outlined by the Work Plan. Based on the information gathered from the first phase of operation the tests and operational scheme may be adjusted for additional testing in the second phase, which is also scheduled for approximately 4 months of operation

1.2 Objectives

The primary objective of the SAP is to identify the sample locations, describe sample collection procedures, and provide guidelines for the water quality analyses. The SAP will also discuss the laboratories involved in the water quality analyses and describe the established QA/QC procedures.

Section 2: Pilot System Sampling Requirements

Figure 2-1 shows the sampling locations for the overall test set-up. Table 2-1 provides a summary of the identification codes and descriptions of the sample locations.

The source water for the demonstration study will be from the produced water reinjection pipeline. A slipstream will be installed off of the pipeline to supply the water for treatment.

2.1 Sample Locations

The goal of this project is to design, construct, and operate a demonstration plant at Area's San Ardo Oilfield to demonstrate that produced water can be treated to meet the project goals. The demonstration plant design will build on the DOE funded project that was completed at the Placerita Canyon oilfield. The demonstration plant will include warm softening to remove silica and hardness. A ClariCone separation unit will be used to remove the precipitated solids from the produced water stream. The treated effluent will then be cooled from approximately 190°F inlet temperature to less than 115°F via a cooling tower. Then, sodium hydroxide and antiscalants are mixed into the stream before filtration through 5-micron cartridge filters. The stream is then treated by reverse osmosis before discharge of the permeate and reject back to the produce water reinjection stream.

The following describes sample locations for the demonstration plant.

2.1.1 Source Water

Source water for the demonstration plant will be from a slipstream that is tapped into the existing Aera Energy LLC oil field reinjection pipeline. Sample location SF010 will provide data to identify the characteristics of the untreated produced water.

2.1.2 Warm Precipitative Softener

The raw produced water will first be treated to remove silica and hardness. Sample location SF020 will be after the ClariCone unit that is designed to remove the solids (silica and hardness) precipitated out from the chemical addition. Silica needs to be reduced in the inlet stream as it reduces the performance of the reverse osmosis system. Sample location SF030 and SF040 will be of the ClariCone sludge. SF030 will be a sample of the dewatered solids and SF040 will be a sample of the decanted water from the solids sludge.

2.1.3 Cooling Tower

The softened water will be cooled using a cooling tower to bring the water temperature from 190 F to below 115 F (acceptable temperature for the reverse osmosis unit). Sample location CT010 will be at the effluent of the cooling tower to identify changes in the water characteristics due to reduction of temperature.

2.1.4 Cartridge Filter

Sodium hydroxide and antiscalants will be added to the cooling tower effluent before it is filtered using 5-micron cartridge filters. Sample location CF010 will be located at the effluent side of the cartridge filters.

2.1.5 Reverse Osmosis Inlet

Sample location RO010 will be of the combined reverse osmosis inlet, which includes the cartridge filter effluent and the recirculation stream from the reverse osmosis unit. Sample location RO020 will be of the system permeate. Sample location RO030 will be of the reverse osmosis system concentrate. RO040 will be of the wastewater from periodic cleaning of the reverse osmosis membrane. In addition to the metals analysis, some additional analyses may be conducted on the membrane cleaning wastewater in accordance with membrane vendors' recommendations.

Section 3: Sample Handling, Analytical Methods, and Laboratory

Samples will be collected from the demonstration plant processes to characterize the raw produced water and treated water at the various locations through the treatment process. Field measurements will be made to benchmark the daily performance of the treatment processes and to assist in determining if adjustments are needed to process units. The following contract laboratories will perform more detailed laboratory analyses: Trusdail Laboratory at Tustin, CA and TOXSCAN Laboratory at Watsonville, CA to document the effectiveness of the treatment processes and the anticipated quality of the treated water and residual streams. Table 3-1 provides a summary of the sample analyses and sample frequency for each sample location.

3.1 Field Measurements

Table 3-1 provides a summary of the water quality parameters to be measured in the field at various sampling locations on a daily basis. Demonstration plant staff will take samples during plant operations and perform the field analyses using onsite equipment located at the Aera Energy LLC facility.

3.1.1 Sample Containers

Field samples will be collected in labeled plastic 1-L bottles. There is no preservative required, but the samples will be chilled if analyses are not conducted immediately following the sampling event.

3.1.2 Sampling and Sample Handling

Sample collection will occur in the morning and afternoon every day by plant personnel. These bottles will be rinsed with fresh sample water prior to collection. Once the analyses are complete, these samples will be disposed of into the onsite storage tank for produced water to be reinjected into the Area oil field. The bottles will be rinsed with distilled water for use at the next sampling event.

3.1.3 Field QA/QC

Where appropriate (e.g., once per treatment condition), field measurements will be taken from split samples collected for both field analysis and analysis by a fixed analytical laboratory. A comparison between the operators' and a certified laboratory analyst will also be conducted at the start of sampling to verify proper analytical technique. All instruments will be properly calibrated and maintained according to manufacturer instructions. Equipment calibration results will be recorded and maintained onsite with the appropriate instrument.

3.2 Contract Laboratory Analyses

Table 3-1 also provides a summary of the laboratory water quality analyses to be performed on a weekly or less frequent basis. The contract laboratory, Trusdail Laboratories, will perform the analyses. Some specialized analyses to evaluate compliance with California Toxics Rule will be

conducted by TOXSCAN Laboratories, due to the low detection limit requirements for these analyses.

Table 3-2 provides a summary of the method detection limits and reporting limits for each of the analyses performed by the associated laboratory (most of the California Toxic Rule required analyses information is presented in Appendix A).

3.2.1 Sample Containers/Preservation

Samples to be sent to the contract laboratory will be collected in bottles provided by the contract laboratory. The number and type of bottles provided may vary depending on analyses to be conducted that week. These bottles should be sorted and labeled prior to collection. When required, the samples bottles will already contain the necessary preservative for the analyses. Table 3-3 provides a summary of the required container, volumes, and preservative required for each of the analyses.

3.2.2 Sampling and Sample Handling

The plant operator will collect samples in accordance with the frequency presented in Table 3-1. Samples that do not contain preservative will be rinsed with sample prior to collection. During sample collection the sample ports will be opened for a short period of time to purge potential stagnant water and debris from the sample port. Samples for CTR analyses will be collected based on the EPA Method 1669 (Sampling Ambient Water For Trace Metals at EPA Water Quality Criteria Levels).

Samples collected for offsite analysis will be labeled with a unique sample, sample date and time, appropriate analysis and sample preservative. An example of the sample identification system used is as follow: sample collected from location RO010 on 20 October 2003 at 4:00 pm would be RO010-102003-1600 (time in 24-hours).

Following sample collection, the sample information will be recorded on a chain of custody form. The samples will then be placed in a refrigerator or cooler filled with ice. Prior to shipment, samples will be packaged in an ice filled cooler. Packaging will include protecting all glass bottles with bubble wrap or foam packing material. The cooler will be taped closed with the chain of custody inside the cooler and the outside of the cooler labeled with the appropriate project information using the overnight carriers shipping label.

3.2.3 Laboratory QA/QC

The California Department of Health Services has certified the contract laboratories, TOXSCAN and Trusdail. QA/QC data will be provided with the analytical reports.

TABLE 2-1
SAMPLE LOCATIONS AND DESCRIPTIONS

Sample Identification	Sample Description
Source Water	
SF010	Produced water from reinjection pipeline
Water Softener	
SF020	Softened produced water
SF030	Sludge solids
SF040	Decanted sludge water
Cooling Tower	
CT010	Cooling tower water effluent
Cartridge Filter	
CF010	Cartridge filtered water
Reverse Osmosis Unit	
RO010	Combined inlet water to the RO unit
RO020	Combined system permeate
RO030	Concentrate stream
RO040	Membrane cleaning wastewater

TABLE 3-1
SAMPLE ANALYSES, LOCATION, AND FREQUENCY

Water Parameters	SF010 Influent	SF020 Softener Effluent	SF030 Warm Lime Feed	SF040 Warm Lime Feed	CT010 Cooling Tower Effluent	CF010 Cartridge Filter Effluent	RO010 Combined RO Inlet	RO020 System Permeate	RO030 System Concentrate	RO040 Membrane Waste Water
Field Readings										
Flow Rate	D	D				D		D		
Total Flow Rate		D								
Flow Calibration		D						D	D	
Pressure	D					D	D	D	D	
Temperature		D			D		D	D		
Field Analyses										
pH	D	D			D	D	D	D	D	
Conductivity	D						D	D	D	
Turbidity	D	D				D				
Silt Density Index							D			
Alkalinity	D	D					3C		3C	
Total Hardness	D	D							3C	
Calcium		D							3C	
UV	D	D						D		
SiO_2	D	D						D	3C	
Oil & Grease	D		3C	3C		D				

TABLE 3-1 (CONT)
SAMPLE ANALYSES, LOCATION, AND FREQUENCY

Water Parameters	SF010 Influent	SF020 Softener Effluent	SF030 Warm Lime Sludge Solids	SF040 Warm Lime Sludge Water	CT010 Cooling Tower Effluent	CF010 Cartridge Filter Effluent	RO010 Combined RO Inlet	RO020 System Permeate	RO030 System Concentrate	RO040 Membrane Waste Water
Laboratory Analyses										
pH	3C	3C	3C	3C	3C				3C	
Alkalinity			3C	3C					3C	
Carbon Dioxide	C		3C	3C		C				
Boron	D	D						D	3C	
Iron	3C	3C	3C	3C					3C	
SiO_2	D	D	3C	3C					3C	
TOC	D	D			C			D		
NH3	D	D			3C			D		
Total Suspended Solids		D								
Total Dissolved Solids								3C	3C	
Heavy Metals	C	C	3C	3C				C	C	C

TABLE 3-1 (CONT)
SAMPLE ANALYSES, LOCATION, AND FREQUENCY

Water Parameters	SF010 Influent	SF020 Softener Effluent	SF030 Warm Lime Sludge Solids	SF040 Warm Lime Sludge Water	CT010 Cooling Tower Effluent	CF010 Cartridge Filter Effluent	RO010 Combined RO Inlet	RO020 System Permeate	RO030 System Concentrate	RO040 Membrane Waste Water
Laboratory Analyses										
California Toxic Rule Analytes[a]		C						C	C	
Cations	3C	3C	3C	3C						
Anions	3C	3C	3C	3C						
Percent Solids			3C							

Notes:
D – 2 samples collected daily (morning and afternoon)
C – 1 sample collected each treatment condition
3C – 3 samples collected per treatment condition
a – List of California Toxic Rule Analyses:
Semivolatiles (method updated from USEPA 8270 to 8270C), Metals, Cyanide, Pesticides/PCBs, Volatiles (method USEPA 524.2), Asbestos, 1,4 Dioxane, Dioxin (singly), Dioxin (all congeners plus furans), Total Petroleum Hydrocarbons, and Perchlorate. See Appendix A

TABLE 3-2
METHOD DETECTION LIMITS AND REPORTING LIMITS FOR LABORATORY ANALYSES[c]

WQ Parameters	Method	Method Detection Limit[(a)]	Minimum Reporting Limit[(a)]	Laboratory[(b)]
1. General Physical				
Alkalinity, Total (as $CaCO_3$)	SM 2320B	10	10	Field + TL
Dissolved Solids, Total (TDS)	SM 2540 C	40	40	TL
Hardness, Calcium	Hach 8222	2.0	2.0	Field
Hardness, Total	Hach 8226	2.0	2.0	Field
Organic Carbon, Total (TOC)	SM 5310C	0.5	0.5	TL
pH	SM 4500 H	0.1 Unit	0.1 Unit	Field + TL
Silt Density Index	ASTM D-4189-95			Field
Solids, Percent	SM 2540 G	0.1 percent	0.1 percent	TL
Specific (Electric) Conductance	SM 2510 B	1 µmhos/cm	1 µmhos/cm	Field
Suspended Solids, Total	EPA 160.2	4	4	TL
Temperature	SM 2550B	0.5° C	0.5° C	Field
Turbidity	EPA 180.1	0.05 NTU	0.05 NTU	Field
UV Absorbance (at 254nm)	SM 5910B	0.009 l/cm	0.009 l/cm	Field
2. General Minerals				
Calcium	EPA 200.7	1.0	1.0	Field + TL
Chloride	EPA 300.0	1.0	1.0	TL
Magnesium	EPA 200.7/ EPA 6010	1.0	1.0	TL
Nitrate (as NO3)	EPA 300.0	0.4	0.4	TL
Potassium	EPA 200.7	1.0	1.0	TL
Sodium	EPA 200.7	1.0	1.0	TL
Silica	ASTM D-859A			Field + TL
Sulfate	EPA 300.0	1.0	1.0	TL
3. Additional Inorganics				
Aluminum	EPA 200.8/ EPA 6010	0.05	0.05	TL
Antimony	EPA 200.8/ EPA 6010	0.006	0.006	TS
Arsenic	EPA 200.8/ EPA 6010	0.002	0.002	TS
Barium	EPA 200.8/ EPA 6010	0.01	0.01	TL+TS
Beryllium	EPA 200.8/ EPA 6010	0.001	0.001	TS
Cadmium	EPA 200.8/ EPA 6010	0.001	0.001	TS
Chromium, total	EPA 200.8/	0.01	0.01	TL+TS

WQ Parameters	Method	Method Detection Limit[(a)]	Minimum Reporting Limit[(a)]	Laboratory[(b)]
	EPA 6010			
Chromium III	EPA 200.8	10	10	TS
Chromium VI	EPA 218.6	0.3	0.3	TL
Cobalt	EPA 200.8/ EPA 6010	0.020	0.020	TS
Copper	EPA 200.8/ EPA 6010	0.05	0.05	TS
Iron	EPA 200.7/ EPA 6010	0.05	0.05	TL
Lead	EPA 200.8/ EPA 6010	0.005	0.005	TS
Manganese	EPA 200.7/ EPA 6010	0.01	0.01	Field + TL
Mercury	EPA 245.1/ EPA 6010	0.001	0.001	TS
Molybdenum	EPA 6010	0.005	0.005	TL+TS
Nickel	EPA 200.8/ EPA 6010	0.01	0.01	TS
Selenium	EPA 200.8/ EPA 6010	0.005	0.005	TS
Silver	EPA 200.8/ EPA 6010	0.01	0.01	TS
Thallium	EPA 200.8/ EPA 6010	0.001	0.001	TS
Vanadium	EPA 6010	3.0	3.0	TLL+TS
Zinc	EPA 200.8/ EPA 6010	0.05	0.05	TS

Notes:
(a) Units =mg/l unless otherwise noted.
(b) KJ = Kennedy/Jenks, TS = TOXSCAN Laboratories, TL = Trusdail Analytical Laboratories
(c) Appendix A contains a list of analytes for the analyses conducted in accordance with California Toxic Rule

TABLE 3-3
SAMPLE HANDLING GUIDE FOR LABORATORY ANALYSES

WQ Parameters	Method	Container[a]	Suggested Volume	Preservative Agent[b]	Holding Time
1. General Physical					
Alkalinity, Total (as $CaCO_3$)	SM 2320B	PE	500 ml	4°C	14 Days
Chlorine Residual, Total	SM 4500Cl G	PE	10 ml	4°C	Immediate
Color	SM 2120 C	PE	500 ml	4°C	2 Days
Dissolved Solids, Total (TDS)	SM 2540 C	PE	500 ml	4°C	7 Days
Hardness, Calcium	Hach 8222	PE	500 ml	H_2SO_4	6 Months
Hardness, Total	Hach 8226	PE	500 ml	H_2SO_4	6 Months
Organic Carbon, Total (TOC	SM 5310C	VOA	2 x 40 ml	H_2SO_4	28 Days
pH	SM 4500 H	PE	250 ml	None	Immediate
Saturation Index	calculation	NA	NA	NA	NA
Silt Density Index	ASTM D-4189-95	NA	NA	None	Immediate
Solids, Percent	SM2540 G	G	8 oz	4°C	7 Days
Solids, Total	SM 2540 B	G	8 oz	4°C	7 Days
Specific (Electric) Conductance	SM 2510 B	PE	1 L	4°C	28 Days
Suspended Solids, Total	EPA 160.2	PE	500 ml	4°C	7 Days
Temperature	SM 2550B	PE	1 L	None	Immediate
THM Formation Potential	SM 5710D	AG / VOA	2 x 250 ml / 2 x 40 ml	4°C / Ascorbic Acid	7 Days
Turbidity	EPA 180.1	PE	500 ml	None	2 Days
UV Absorbance (at 254nm)	SM 5910B	PE	250 ml	4°C	24 hours
2. General Minerals					
Calcium	EPA 200.7	PE	500 ml	HNO_3	6 Months
Chloride	EPA 300.0	PE	100 ml	None	4 Weeks
Magnesium	EPA 200.7/ EPA 6010	PE	500 ml	HNO_3	6 Months
Nitrate (as NO_3)	EPA 300.0	PE	100 ml	H_2SO_4	2 Days
Potassium	EPA 200.7	PE	500 ml	HNO_3	6 Months
Sodium	EPA 200.7	PE	500 ml	HNO_3	6 Months
Silica	ASTM D-859A	PE	250 ml	None	28 Days
Sulfate	EPA 300.0	PE	1 L	None	4 Weeks
3. Additional Inorganics					
Aluminum	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Antimony	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Arsenic	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Barium	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Beryllium	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Cadmium	EPA 200.8/6010	PE	500 ml	HNO_3	6 Months
Chromium, total	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months

WQ Parameters	Method	Container[(a)]	Suggested Volume	Preservative Agent[(b)]	Holding Time
Chromium III	EPA 200.8	PE	500 ml	HNO_3	6 Months
Chromium VI	EPA 218.6	PE	500 ml	None	24 Hours
Cobalt	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Copper	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Iron	EPA 200.7/ EPA 6010	PE	500 ml	HNO_3	6 Months
Lead	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Manganese	EPA 200.7/ EPA 6010	PE	500 ml	HNO_3	6 Months
Mercury	EPA 245.1/ EPA 6010	VOA	80 ml	HNO_3	28 Days
Molybdenum	EPA 6010	PE	500 ml	HNO_3	6 Months
Nickel	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Selenium	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Silver	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Thallium	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months
Vanadium	EPA 6010	PE	500 ml	HNO_3	6 Months
Zinc	EPA 200.8/ EPA 6010	PE	500 ml	HNO_3	6 Months

Notes:
(a) AG = Amber-Glass; VOA = glass VOA-vial, PE = polyethylene
(b) HNO_3 = nitric acid;H_2SO_4 = sulphuric acid.

Appendix D

Kennedy/Jenks Consultants

2151 Michelson Drive, Suite 100
Irvine, California 92612-1311
949-261-1577
949-261-2134 (Fax)

Site Health and Safety Plan

San Ardo Oilfield

San Ardo, California

For

Cooperative Agreement No: DE-FC26-02NT15463

Recovery of More Oil-in-Place at Lower Production Costs while Creating a Beneficial Water Resource

4 June 2003

Prepared for

Aera Energy LLC
10000 Ming Avenue
Bakersfield, CA 93389

K/J Project No. 024033.00

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List of Tables

Site Health and Safety Plan Summary

Site Name: Aera Energy LLC, San Ardo, CA Demonstration Plant

Address: San Ardo Oilfield

Site Telephone: To Be Determined

Project Start Date: To Be Determined

K/J Job Number: 024033.00

Site Safety Officer (SSO): Sunny Huang

Project Manager: Larry Leong

Type of Investigation:

Sampling Investigation:
- ☐ Hand Auger
- ☐ Drilling
- ☐ Trenching
- ☐ Well Installation
- ☐ Soil Sampling
- ☐ Groundwater Sampling
- ☒ Other: _Treatment Plant Operation____

Site Remediation:
- ☐ Excavation
- ☐ Treatment System Installation
- ☐ UST Removal

☐ Site Walk-through ☐ Other: _____

Potential Hazards:

☐ Organics ☐ Solvents ☒ Bases
☐ Inorganics ☐ Pesticides ☐ Fire/Explosion
☐ Metals ☐ Acids ☐ Other: _____

Personal Protective Equipment:

☐ Level C
☒ Level D

Section 1: Introduction

This Site Health and Safety Plan[Comment1] establishes general health and safety protocols for Kennedy/Jenks Consultants (Kennedy/Jenks) personnel at the Aera Energy LLC Produced Water Pilot Study Treatment Plan[Comment2] located at the San Ardo Oilfield, Monterey County, California[Comment3]. This Plan has been developed in Consultation with Health and Safety Officers at Aera Energy LLC site. As needed, addenda containing activity-specific health and safety protocols will be prepared and attached to this Site Health and Safety Plan prior to the initiation of each additional field activity. The Site Health and Safety Plan and activity-specific addenda, as a minimum, contain the following information:

- Names of key personnel and alternates responsible for site health and safety and appointment of a Site Safety Officer.
- A health and safety risk evaluation for each site task and operation.
- Personal protective equipment to be used by employees for each site task and operations being conducted.
- Medical surveillance requirements.
- Frequency and types of air monitoring, personal monitoring and environmental sampling techniques and instrumentation to be used. Methods of maintenance and calibration of monitoring and sampling equipment to be used.
- Site control measures.
- Decontamination procedures.
- Site's standard operating procedures.
- An Emergency Response Plan that addresses effective site response to emergencies.

For informational purposes only, this plan may be provided to subcontractors of Kennedy/Jenks involved in activities at the Site, interested regulatory agencies, or others. However, entities and personnel other than Kennedy/Jenks shall be solely responsible for their own health and safety and shall independently assess onsite conditions and develop their own health and safety protocols incorporating the requirements of Aera Energy LLC. Entities or personnel that anticipate using health and safety measures which are less stringent than Kennedy/Jenks' measures should immediately contact the Kennedy/Jenks Site Safety Officer (SSO).

Kennedy/Jenks has developed a corporate health and safety program (Kennedy/Jenks Consultants, Industrial Services Group, Corporate Health and Safety Program, June 1991). The corporate program complies with current health and safety regulations, including OSHA 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response, and CalOSHA Standards (8 CCR 5192). Many of the protocols of the corporate program are conducted on a routine basis (general training, respirator fit testing, general medical record keeping, etc.) and are not repeated herein. The corporate program is available to Kennedy/Jenks employees. Questions regarding the corporate program are referred to the Kennedy/Jenks Regional Safety Supervisor.

A copy of the Site Health and Safety Plan along with any addenda containing activity specific health and safety information will be kept in a conspicuous location at all times while work is being conducted at the site.

Section 2: Key Health and Safety Personnel

The Kennedy/Jenks SSO is Sunny Huang[Comment4]. In the absence of the SSO during field activities, a member of the site operators team will be designated as the Kennedy/Jenks Field Site Safety Officer (FSSO). The SSO or FSSO is responsible for the following.

- Observing field activities for compliance with this Site Health and Safety Plan, applicable addenda, and Kennedy/Jenks' Corporate Health and Safety Program.
- Maintaining the onsite medical surveillance, if required, and emergency medical treatment programs, and assisting in onsite emergencies.
- Modifying health and safety protocols or terminating field work when unsafe work conditions exist.
- Familiarizing personnel with health and safety protocols.
- Observing that field personnel wear appropriate personal protective equipment.
- Evaluating potential hazards.
- Recording the occurrence of any site injury or illness.

If unsafe conditions are encountered, if illness or injury occurs, or if the level of protection needs to be changed, the SSO or FSSO will consult in a timely manner with the Project Manager, Larry Leong[Comment5], or the Corporate Industrial Hygienist, Bert Drews[Comment6].

Section 3: Site Description and History

Kennedy/Jenks Consultants will conduct a pilot study at the San Ardo Oilfield to assess treatment technologies for produced water from the oil production process. The goal of this project is to evaluate the potential of eliminating or reducing the volume of produced water reinjected into the formation following oil recovery activities. The benefits from eliminating the reinjection of produced water may be an increase the oil yield from the formation, reduction in energy costs associated with reheating the reinjected produced water, and providing an alternative source of potable water to nearby users.

The San Ardo Oilfield is located in Monterey County in central California, approximately 45 miles north of the city of San Luis Obispo. There are two oilfield operators in the San Ardo Oilfiled, Aea Energy LLC and Chevron Texaco. Aera Energy LLC's portion of the San Ardo Field covers an area of over 2,600 acres. The field consists of two main oil reservoirs, the Aurignac and the Lombardi. Both reservoirs are currently being produced using continuous steam injection. Field volumes for March 2002 were 8,294 barrels of oil per day, 44,015 barrels of steam per day, and 89,800 barrels of water disposal per day. Monterey County is the fifth largest crude oil producing county in California (Department of Conservation, 2001).

In order to stop Class II injection of the excess produced water, it is necessary to identify an appropriate alternative method for managing produced water. Alternatives include treatment for NPDES discharge into streams for groundwater recharge and/or treatment for beneficial use. This project is intended to show potential water users and regulatory agencies that produced water can be reliably treated to a quality acceptable for NPDES discharge, agricultural, or non-flange to flange municipal beneficial reuse.

After construction of the demonstration plant and system startup, it is estimated that the pilot study will be completed in two phases and be conducted over an eight month operating period to demonstrate that produced water can be treated to meet the following: 1) those criteria required by Aera Energy LLC; 2) those criteria required by the regulatory agencies; and 3) those criteria required by the end users of the treated water.

The first phase of operation will provide operational data on the technologies and operating procedures outlined by the Work Plan. Based on the information gathered from the first phase of operation the tests and operational scheme may be adjusted for additional testing in the second phase, which is also scheduled for approximately 4 months of operation.

Section 4: Planned Site Activities

The goal of this project is to design, construct, and operate a demonstration plant at Aera Energy LLC's San Ardo Oilfield to demonstrate that produced water can be treated to meet the project goals. The demonstration plant design will build on the DOE funded project that was completed at the Placerita Canyon oilfield. The demonstration plant will include warm softening to remove silica and hardness. Several chemicals will be used for this portion of the test. They include; virgin caustic, waste caustic, magnesium chloride, sodium hydroxide, dolomitic lime, and polymer chemicals. A ClariCone separation unit will be used to remove the precipitated solids from the produced water stream. The treated effluent will then be cooled from approximately 190 F inlet temperature to less than 115 F via a cooling tower. Then, sodium hydroxide and antiscalants are mixed into the stream before filtration through 5 micron cartridge filters. The stream is then treated by reverse osmosis before discharge of the permeate and reject back to the produce water reinjection stream.

The facility is anticipated to be constructed on a ½ acre of the San Ardo Oilfield. Construction will include installation of concrete pads and electrical service to be provided by Aera Energy LLC. Aera Energy LLC will be responsible for construction of the demonstration plant per Kennedy/Jenks designs and engineering support.

Following construction of the demonstration plant. Kennedy/Jenks and Aera Energy LLC will work together to test the system and complete the startup and shakedown phase of the project. Once the demonstration plant is deemed operational the system will be operated 24 hours a day, Monday through Friday. The plant will not operate on the weekends. Kennedy/Jenks will provide an onsite operator for approximately 8 hours each Monday through Friday. This work plan is intended to address safety issues related to the operation of the demonstration plant. Field staff will be familiar with this document and undergo all training required by Aera Energy LLC to be eligible to work on the demonstration plant site.

Section 5: Health and Safety Hazard Assessment

5.1 Potential Physical Hazards

Field personnel should be cognizant of potential physical hazards associated with use of heavy equipment and electrical equipment during field operations. Appropriate precautions include the following:

- ANSI-approved hardhats, safety glasses or goggles, and steel-toe boots will be worn.
- Loose clothing that may catch in moving parts will not be worn.

Prior to installation of equipment, a utility survey shall be conducted to identify overhead electrical hazards and potential ground hazards, such as underground storage tanks or underground utilities.

5.1.1 Excavation

Field personnel should not enter any excavations exceeding 5 feet in depth unless the excavations are properly shored, braced or sloped and a safety ladder is provided for ready access or egress. Twenty-four hours prior to any excavation activity underground service alert should be notified.

5.1.2 Confined Space Entry

Kennedy/Jenks personnel will not enter any confined space without advanced specific preparation, planning, training, and supervision by the Regional Safety Supervisor. A confined space is defined by OSHA as the concurrent existence of the following conditions.

- Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- Is not designed for continuous employee occupancy.

5.1.3 Tripping and Falling Hazards

Piping, hoses and other equipment may pose a tripping hazard at the site. Since most of the equipment will be installed above ground care should be taken when moving around the site. Obstacles that are obvious tripping hazards will be marked with caution tape to alert site employees and visitors.

5.1.4 Heat Stress

At times site conditions may pose a threat from a heat stress standpoint. The reported normal seasonal temperatures at the site range to approximately 90[Comment7]°F. However, maximum temperatures historically have reached temperatures exceeding 110°F at the site. In addition

the heat from the operating equipment and heat radiating from the inlet piping with produced water at temperatures of approximately 190°F may also contribute to heat stress. Preventative measures should include the following:

- Water and/or commercial electrolyte solutions will be available and drinking of these fluids will be encouraged. The water will be kept reasonably cool

Personnel exhibiting symptoms of heat stress (nausea, cramps, dizziness, clammy skin) will be removed from the work area, cooled, fluids will be administered, and the personnel will be observed. Personnel exhibiting symptoms of heat stroke (hot dry skin, mental confusion, unconsciousness) will be immediately cooled and taken to the hospital.

5.2 Hazardous Substances and Other Onsite Chemicals

It is anticipated that several hazardous chemicals will be used as part of the treatment process at the demonstration plant. These chemicals are 20 percent to 40 percent virgin and waste caustic and sodium hydroxide. In addition to these hazardous chemicals additional chemicals will be onsite. These include; magnesium chloride, dolomitic lime, ClariCone polymer, and antiscalant/antifoulant. [Comment8]Field personnel will minimize potential chemical hazards by avoiding direct contact with any chemical and feed water.

5.2.1 Virgin/Waste Caustic

Virgin and waste caustic at between 20 percent to 40 percent concentrations will be used to remove hardness from the influent water. It will be stored in a polyethylene tank with secondary containment. It will be delivered using a metering pump by direct feed into the ClariCone mixing unit. Worker exposure during normal operations is expected to be minimal. Appropriate precautions include the following:

- The storage tank will be labeled appropriately,
- All work and operating adjustments related to the caustic storage tank, metering pump, and associated feed lines will be conducted using a face shield over safety glasses and rubber gloves.
- Eye wash station will be located in close proximity to the caustic storage tank.
- The caustic storage tank will be located in a well-ventilated area.
- Adsorbent material will be stored nearby in case of a spill. Site personnel will familiarize themselves with the appropriate spill containment procedures for caustic that are described in the MSDS.

5.2.2 Sodium hydroxide

Sodium hydroxide will added to at the ClariCone mixing unit and the cooling tower effluent. It will be stored in a polyethylene tank with secondary containment and delivered to the process stream using two metering pumps. Worker exposure is expected to be minimal. Appropriate precautions include the following:

- The storage tank will be labeled appropriately,
- All work and operating adjustments related to the sodium hydroxide storage tank, metering pump, and associated feed lines will be conducted using a face shield over safety glasses and rubber gloves.
- Eye wash station will be located in close proximity to the sodium hydroxide storage tank.

- The sodium hydroxide storage tank will be located in a well-ventilated area.
- Adsorbent material will be stored nearby in case of a spill. Site personnel will familiarize themselves with the appropriate spill containment procedures for sodium hydroxide that are described in the MSDS.

5.2.3 Dolomitic Lime

Dolomitic lime will be stored in a polyethylene tank with secondary containment. It will be delivered using a metering pump by direct feed into the ClariCone mixing unit. Worker exposure during normal operations is expected to be minimal. Appropriate precautions include the following:

- The storage tank will be labeled appropriately,
- All work and operating adjustments related to the caustic storage tank, metering pump, and associated feed lines will be conducted using a face shield over safety glasses and rubber gloves.
- Eye wash station will be located in close proximity to the storage tank.
- The caustic storage tank will be located in a well-ventilated area.
- Adsorbent material will be stored nearby in case of a spill. Site personnel will familiarize themselves with the appropriate spill containment procedures for dolomitic lime that are described in the MSDS.

5.2.4 Other Chemicals

A proprietary polymer as well as antiscalant/antifoulant will be stored in polyethylene tanks with secondary containment. These chemicals will be delivered using a metering pumps by direct feed into the process system. Worker exposure during normal operations is expected to be minimal. Appropriate precautions include the following:

- The storage tank will be labeled appropriately,
- All work and operating adjustments related to these tanks, metering pumps, and associated feed lines will be conducted using safety glasses and protective gloves.
- Eye wash station will be located in close proximity to these storage areas.
- Adsorbent material will be stored nearby in case of a spill. Site personnel will familiarize themselves with the appropriate spill containment procedures for these chemicals that are described in the MSDSs.

5.3 Hot Equipment

It is anticipated that piping and process units for the inlet produced water may reach temperatures up to 190°F. Site staff and visitors will be alerted about the hot equipment upon their first arrival on site. In additional the accessible hot piping or process equipment will be marked with labels or signs to mark them as hot and potential burn hazards.

Section 6: Protective Actions

6.1 Personnel Protective Equipment

Field personnel will wear equipment to protect against the potential physical and chemical hazards, which have been identified herein, and those that become apparent in the field. Level D protection will be required at a minimum for field activities at the site. Level D personal protective equipment to be used will include:

- ANSI-approved hard hat
- Chemical resistant gloves - disposable PVC or nitrile when exposed to chemicals or process water
- Boots, steel toe and shank
- Work clothes or Tyvek
- ANSI-approved safety glasses
- Safety goggles or a face shield should be used when a foreseeable splash hazard exists
- Disposable hearing protection during high-noise activities

The level of protection employed may be upgraded, as deemed necessary by the SSO or FSSO.

If non-routine field activities are initiated, the level of protection will be specified in the activity-specific health and safety addenda.

6.2 Site Control

Site control measures will be established with Aera Energy LLC site personnel. Site security measures will include restrictive fencing around the facility. The site will be secured by a lockable gate when project personnel are not onsite. A visitors and employees log will be kept to document onsite personnel. Everyone that comes on site will be required to sign in and out upon arrival and departure. No unauthorized visitors will be allowed on site.

6.3 Training

Kennedy/Jenks personnel participating in field activities will have completed site specific health and safety training that covers the information presented in this Health and Safety Plan. In addition, all personnel will be required to complete the necessary training required by Area for workers in the San Ardo Oilfield. Routine safety meetings will be held to reiterate the site safety concerns and to identify additional safety issues.

6.4 Sanitation and Illumination

The site will have drinking water, washing water, and restroom facilities available. Operational activities will take place during daylight hours. Because natural illumination (approximately 50 to 200 foot candles) will be sufficient to meet the 5-foot candle requirement for general site areas, no additional illumination will be required.

Section 7: Emergency Response Plan

Hazard recognition is an essential part of the Emergency Response Plan. Initiation of the contingency plan relies on the employee's ability to recognize an emergency or potential for an emergency. The following is a list of events, which will immediately initiate emergency procedures:

- Explosion
- Fire
- Release of organic vapors or particulate above the action levels
- Personal injury
- Failure or expected failure of runon/runoff control measures
- Natural occurrences (i.e., lightning, tornado, high winds, etc.)
- Spills

7.1 Emergency Communications

Emergency communications will consist of two methods.

7.1.1 Verbal Communication

Verbal communication will be the primary method of emergency communication between onsite personnel, distance permitting.

7.1.2 Telephones

Telephones are used for routine communication and to notify offsite agencies of incidents and request assistance. Emergency telephone numbers are given in Table 1.

7.2 Emergency Protocol

When an event recognized as an emergency occurs, the alarm system will be used to notify personnel. As soon as the alarm system is activated, the SSO or FSSO will be notified.

The SSO or FSSO will take into account the following information:

- Nature of emergency
- Wind direction
- Location of personnel
- Emergency equipment available

Based on this information, the SSO or FSSO will direct appropriate emergency action and agency notification. After the emergency has been controlled and the site is considered safe to re-enter, the SSO or FSSO will direct remedial action to restore the site to full operating condition.

The SSO or FSSO will investigate the nature and cause of the incident so that work procedures can be modified to minimize the likelihood of the incident's recurrence. All incidents must be reported in a timely, appropriate manner. An incident is any unplanned event resulting in injury,

damage, loss of assets, adverse publicity, or which requires notification of a regulatory agency, regardless of severity. All Kennedy/Jenks personnel should report an incident to the SSO or FSSO. The SSO and FSSO will report to the project manager. Each incident will be investigated and a written report should be received by the project manager and the regional safety supervisor within five days of the incident.

7.3 Emergency Supplies

Onsite emergency equipment will include equipment used during operations. The following is a list of emergency equipment available to take to the site.

- Portable emergency eye wash
- Tarps/space blankets to reduce contamination potential while transporting injured personnel to medical facilities.
- Twenty-pound ABC fire extinguishers
- First-aid supplies
- Absorbent-spill control
- Extra batteries for radios, cell phones, etc.

All personnel will have a thorough understanding of the Emergency Response Plan before starting work. It will be reviewed periodically to keep it current with new or changing site conditions or information.

7.4 Injury Response

In the event of personal injury, first-aid personnel must decide if the victim's injuries are potentially the type that would be aggravated by movement. If there is any doubt, or the victim is unconscious and cannot respond, no attempt should be made to move the victim to the decontamination area. Only offsite paramedics may move such victims. Routine and emergency communication will be provided by the site telephone.

Section 8: Signatures

Site Safety Officer: _____ Date: _____

Regional Safety Supervisor: _____ Date: _____

Project Manager: _____ Date: _____

Tables

Table 1: Emergency Information

Emergency Telephone Numbers	
In Emergency	911
Site Telephone	*****[Comment9]
Hospital: *****[Comment10]	
Directions to hospital: *****[Comment11]	
Ambulance	911
Police	911
Fire Department	911
Kennedy/Jenks Consultants:	
Project Manager	*****[Comment12]
Regional Safety Supervisor	*****[Comment13]
Site Safety Officer	*****[Comment14]
Corporate Safety Officer	*****[Comment15]